BOTANY

Volume LXXXI Number 1

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The BOTANICAL GAZETTE

FOUNDED BY JOHN M. COULTER

MARCH 1926

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Volume LXXXI Number 1

THE BOTANICAL GAZETTE

A JOURNAL EMBRACING ALL DEPARTMENTS OF BOTANICAL SCIENCE

EDITED BY

JOHN M. COULTER

With the assistance of members of the botanical staff of the University of Chicago

Issued March 22, 1926

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For March 1926 and April 1926

What Does the Lesson-Learner Learn?

The answer which one educator, Henry C. Morrison, would give to this question, is "Lessons, and, too often, not a great deal more." Professor Morrison has written a book in which, after twenty-five years of experimental study of teaching, he criticizes the present educational system upon this very basis, and develops a coherent theory of education that points the way to more thorough learning and better instruction.

The title of the book, *The Practice of Teaching in the Secondary School*, indicates its scope only when one understands Professor Morrison's conception of the secondary school. He defines it to be that region in the process of education within which the pupil is capable of study but incapable of systematic intellectual growth without the constant aid of the teacher: that is, the period from about the beginning of the fourth grade to the end of the junior college.

The theory of teaching which lays emphasis upon grades, lesson-learning, and lesson-hearing, and which treats the mind of the pupil as a receptacle to be filled is the chief object of Professor Morrison's critical attack. He points out that "students of the educational process from Socrates down have protested" against such a theory; that it "obscures the true learning products"; and that it represents a "mental attitude brought over from the field of industry." He says "The whole theory of necessity eventuates in building up in the developing pupil the conviction that performance is achievement, that very inferior work is acceptable work, and that the most superior performance is still less than full performance."

This book is Professor Morrison's answer in terms of specific procedure to the question of what is to be done to improve upon such a system. It advocates the abandonment of the lesson-learning theory of teaching and the substitution therefor of the direct teaching of the true learning products. These, in the last analysis, are a wide range of interests, and the capacity for independent intellectual life. This is the basis of Professor Morrison's entire theory of teaching. He outlines a technique designed to achieve these ends.

The discussion includes right and wrong methods of estimating the pupil's development; control technique; operative technique in science, history, grammar, mathematics, the practical arts, English, and foreign languages; and administrative technique.

Professor Morrison's book is one that is inspired by the spirit of scientific technique. It looks upon the teacher as a creator and explorer rather than as a routinist.

THE PRACTICE OF TEACHING IN THE SECONDARY SCHOOL. By HENRY C. MORRISON. *$4.00, postpaid $4.15.*

The City

The City and Human Nature

The great city, where nearly everything of which human nature is capable happens daily, has long been the workshop of the writer of fiction. In novels, poems, and stories have thus far appeared the most intimate interpretations of the city and its life. But now, with the publication of *The City* by Robert E. Park, E. W. Burgess, and others, appear the findings of a group of sociologists, who, turning to the fiction writer's chosen province, study it as a social entity. They bring to the task a technique which assures a more searching and disinterested analysis than has previously been attained.

These sociologists are pioneers; they are just now concerned primarily with outlining a program for future investigation of human nature and social life under modern urban conditions. They are making a beginning in the application to the customs, beliefs, and social practices of the denizen of the modern city, of the same patient methods of observation which anthropologists like Boas and Lowie have applied to the life and manners of primitive peoples.

A wide variety of phenomena characteristic of city life have been investigated. Professor Burgess discusses city growth, and Professor McKenzie the ecological approach to the study of the human community. Professor Park comments upon that remarkable product of city life, the metropolitan daily newspaper, and upon human nature as it appears in community organization. He analyzes and explains that "romantic temper" which finds expression in the dance halls. An analysis of the mind of the hobo leads him to general reflections on the relations between mentality and locomotion. Perhaps the most interesting and informative chapter of all is that on "Magic, Mentality, and City Life."

Included in the book is a valuable and extensive bibliography of the urban community by Louis Wirth. It is an index to those aspects of the city which promise most in results from research.

This book is the searching study of the physical organization, the occupations, and the cultures of the city for which those who have recognized in the great city the most interesting of laboratories for the study of man's nature, have been waiting. *THE CITY*. By ROBERT E. PARK, E. W. BURGESS, AND OTHERS. *$2.00, postpaid $2.10.*

* * *

History Not in the Textbooks

For sixty years the general belief has been that the South was overpowered by superior numbers. Frank L. Owsley develops in *State Rights in the Confederacy* a new point of view. He maintains that the Confederacy collapsed more from internal than external causes, and that the most disastrous of these internal ailments was the attempt of the Southern people to practice their theory of state rights during the war.

In support of this thesis, a startling array of evidence is offered. Mr. Owsley cites cases in which various state governments refused arms and men to the Confederate government and even confiscated arms and supplies on the principle of state rights. Much of the material has been drawn from the official records of the Union and Confederate armies, the *Journal of the Confederate Congress*, *Confederate Records of Georgia*, and representative contemporary newspapers.

The book is not an unfriendly attack upon those who fought for the idea of state rights. Mr. Owsley has simply had the interest of a scholar in bringing to light some of the little-known political phases which may be called the seamy side of Confederate history. This unusual historical study uncovers many new facts which have been hitherto unknown even to scholars.

H. L. Mencken, writing of the book in *The American Mercury* says, "This is a small book, but like that other small book, Dr. Charles A. Beard's *The Economic Interpretation of the Constitution*, it is packed with important and revolutionary facts. . . . . Here is news that is not in the schoolbooks —and that will be received very ungracefully, no doubt, in the South. Dr. Owsley is himself a Southerner and associate professor of history at Vanderbilt University, in Tennessee. . . . . But the facts he has amassed will not be disposed of . . . . and no intelligent man will be able to write about the Civil War hereafter without taking them into account. His book is but another symptom of the intellectual awakening that is going on in the South. . . . . Like his colleague, Dr. John D. Wade, of the University of Georgia, he is a man of both ability and courage. It is a combination that the late Confederacy needs sorely. Once enough young Southerners show it, there will be an end of the obscurantism that has oppressed and disgraced the South for half a century." *STATE RIGHTS IN THE CONFEDERACY*. By FRANK L. OWSLEY. *$2.50, postpaid $2.60.*

A Panchatantra Tale

"Not even Brahma sees the end
Of well-devised deceit:
The weaver, taking Vishnu's form
Embraced the princess sweet."

"How was that," asked Cheek, "Are undertakings successful even through deceit, resolutely and well-devised?" And Victor told the story of

THE WEAVER WHO LOVED A PRINCESS

"In the Molasses Belt is a city called Sugarcane City. In it lived two friends, a weaver and a carpenter. Since they were past masters in their respective crafts, they earned enough money by their labors so that they kept no account of receipt and expenditure. They wore soft, gaily-colored, expensive garments, adorned themselves with flowers and betel leaves, and diffused odors of camphor, aloes, and musk. . . . . They made the rounds of the spots where society gathered—theaters, *conversaziones*, birthday parties, banquets, and the like—then went home at twilight. And so the time passed.

"One day there was a great festival. . . . . The weaver and the carpenter put on their best things, and in the squares and courtyards inspected the faces of people dressed to kill. And they caught a glimpse of a princess seated at the window of a stucco palace. . . . . Like a dream she took captive the eyes of all as she sat surrounded by girl friends.

"And the weaver, ravished by lavish loveliness since the love-god with five fierce arrows pierced his heart, concealed his feelings by a supreme effort of resolution, and tottered home, seeing nothing but the princess in the whole horizon. . . . ."

Thus began the love of the weaver for the princess, and how Vishnu aided the weaver to attain his heart's desire is related in the rest of this charming tale from *THE PANCHATANTRA*. Translated from the Sanskrit by ARTHUR W. RYDER. *$4.00, post-*

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the problem of presenting their results in popular form, in so far as that can be done without damage to scientific accuracy.

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The series has been the medium which several eminent scientists have taken to give their ideas to the public. John M. Coulter wished to emphasize the fact, not generally appreciated, that sex is not an essential feature in reproduction. In *The Evolution of Sex in Plants* he showed that in all probability, taking the plant kingdom as a whole, the multiplication of individuals is greater by asexual than by sexual methods. Two decades of investigation convinced Thomas C. Chamberlin that the conception of the earth as a once molten globe enveloped in great, hot atmospheres is incorrect. In *The Origin of the Earth* he presented his own, radically new view of the earth's beginning. In *Individuality in Organisms* Charles Manning Child gave evidence in support of a conception of the nature of organic individuality which he had developed as a result of fifteen years' investigation of the processes of reproduction and development in the lower animals. Robert Andrews Millikan, Nobel Prize winner, described his world-famed experiments in *The Electron*. Albert A. Michelson is giving the essence of his researches on the subject of light in *Studies in Optics* to be published in April. *Write for descriptive catalogue.*

ROBERT A. MILLIKAN

THE CITY

Human Behavior in the Urban Environment

By ROBERT E. PARK, E. W. BURGESS, *and* RODERICK D. McKENZIE

with a bibliography by
LOUIS WIRTH

The city as a social entity has thus far been studied chiefly by writers of fiction, and this book has been written in the belief that the time has come for a more searching and scientific treatment. An investigation of human behavior in the city environment and a study of urban life—its physical organization, its occupations, and its cultures—this volume treats the city as a product of human nature, rather than a bare artificial mechanism.

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There is a valuable and extensive bibliography by Louis Wirth. This is a volume in the "University of Chicago Studies in Urban Sociology."

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VOLUME LXXXI NUMBER 1

THE

BOTANICAL GAZETTE

March 1926

INTERRELATION OF RELATIVE DAY LENGTH AND TEMPERATURE

CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY 343

BASIL E. GILBERT

(WITH FIVE FIGURES)

Introduction

The reactions of the plant to its environment have furnished material for much speculation and scientific investigation. Many interesting scientific facts have resulted from experimentation, during which plants have been subjected to varying combinations of environmental factors. In recent years the phenomenon of the reaction of the plant to varying day lengths has been of outstanding importance. Beyond the fact, however, that it is known that such a phenomenon exists, little is known of the mechanics of the reaction or its relation to the other factors of environment. It has seemed possible that one or other of these factors may bring about the same formative changes as those produced by "relative day length," or failing the discovery of any one definite causal agency, some knowledge may be gained concerning the interaction of one factor with another. The object of this investigation has been an attempt to determine the importance of temperature in determining the time of the initiation of flower primordia in *Xanthium pennsylvanicum*.

The importance of relative day length, or photoperiodism as it has been called, has been stressed greatly as the determining factor in causing flowering, by GARNER and ALLARD (8). Concerning the

interrelation of day length and temperature, they recognize the fact that "temperature is undoubtedly the most important environmental factor in relation to the action of the light period on plant growth," and they cite experiments with soy beans grown under short day conditions and differing temperatures in support of this assertion. The conclusion is drawn that a lower temperature delayed the time of flowering. They also draw attention to the effect of temperature on respiratory activity, and suggest that "in this way the relation between the duration of the light period and the prevailing temperature may be of decisive importance." WANSER (24) claims that day length independent of temperature will control the type of growth in winter wheat, and that by regulating this environmental factor, jointing and heading may be controlled independently of the season. EATON (5) has recently found that the time of flowering of Peking soy beans can be influenced to an extent comparable with the differences due to varying the day lengths if the plants are subjected to high, low, and uncontrolled nightly temperatures. The situation at the present time seems well summarized by ADAMS (1), who suggests that "much further experimentation will be necessary before any conclusions of a general nature can be drawn as regards the effect of light on the time of flowering." He also concludes that the reproductive activity, as well as the other activities of the plant, depend largely on photosynthesis, and the amount of photosynthesis is largely dependent upon the intensity of the light, its duration, and the temperature.

Closely allied with the experimentation by varying external factors have been efforts to determine the metabolic conditions produced within the plant. Several workers have thrown light on the situation accompanying flower development. KLEBS (13), working with *Sempervivum Funkii*, suggests that at low temperatures soluble sugars accumulate, and thus produce a set of conditions which he calls "ripeness to flower." He assumes an equilibrium between assimilation and dissimilation, and that light and temperature act contrary to each other in influencing this equilibrium. He gives us no data, however, in support of his theory. FISCHER (7) suggests the possibility of a high carbohydrate nitrogen ratio favoring flowering. He also fails to substantiate his theory with data. With the

work of KRAUS and KRAYBILL (16) on the tomato, a more complete conception of the relationship between carbohydrate and nitrogen compounds is given. They have drawn attention particularly to the probability of both carbohydrate and nitrogen becoming limiting under certain conditions, and have shown that, with the tomato at least, a limitation of either of these conditions inhibits flowering. GURJAR (9) has found that the same results hold for tomato, turnip, and radish; and WOO (26) finds that large amounts of carbohydrates are paralleled by low amounts of nitrogen in *Amaranthus*. NIGHTINGALE (17) also reports results similar to those of KRAUS and KRAYBILL, and draws attention to the possibility of the greater significance of insoluble nitrogen than total or nitrate nitrogen. HARVEY and MURNEEK (10) and other workers in the horticultural field have endeavored to follow up these results with investigations on the fruit bud differentiation in fruit trees. They conclude that while the carbohydrate-nitrogen ratio should not be given a causal relationship in the bringing about of a particular formative change in a plant organ, the ratio is important as an indication of possible limiting situations within the plant. HOOKER and BRADFORD (11) object to any significance being given the ratio, either as a causal agency or a relationship of fundamental importance. Their argument is summarized and the present situation commented upon by SUMMERS (23), who is of the opinion that "the C/N ratio represents a real causal relationship between the nutrient reserves of a tree and the intensity of fruit production." Another summary is given by KNIGHT (14), who draws attention to the possibility of the law of limiting factors operating within the plant, actuated by environmental changes and evidenced by fluctuations in carbohydrates and nitrogen.

There have been few direct examinations of the formative effects of different temperatures. WALSTER (25) summarized the literature up to 1920, and, working with barley, adds his own conclusions that high heat supply coupled with high nitrogen supply inhibits culm formation. JOHNSTON (12) observed that the flowers on the east side of the giant cactus mature and open before those on the other portions of the crown. He found that there was a higher average temperature in the tissues of the east side, and concluded that "this

higher average temperature brings the tissue of the east side nearer the optimum for growth and thus is responsible for the earlier maturing of the flowers of this side." Following a survey of the habitats in which *Zostera marina* is found, SETCHELL (20) was able to demonstrate that the important factor in bringing about formative changes is temperature and not photoperiodism. In the case of reproduction, he found the temperature limits quite definitely marked. Temperatures of 15°–20° C. accompanied the inception of this stage in the life of the plant.

Cultural conditions and chemical methods

A. CULTURAL CONDITIONS.—*Xanthium pennsylvanicum* was chosen as a plant particularly suited for this sort of investigation. It had been observed to give definite responses to temperature, and also is one of the "short-day plants" listed by GARNER and ALLARD. In addition to such advantages, this plant produces a terminal staminate inflorescence, and thus the beginning of the reproductive stage is easily observed. In preparing the seeds for all growth experiments, the burs were cut open and the seeds removed and soaked over night; then the brown testa was readily removable, leaving the ivory white seeds for planting. By this means germination of both upper and lower seeds was insured. The soil used was the greenhouse potting loam, which contained much organic matter, and in no case could the nitrogen supply be considered as limiting. The plants were grown in 12-inch unglazed pots and were watered with city water. The temperature of the greenhouses was controlled by automatic thermo-regulators. Temperature records were kept throughout the complete experimental period, Friez thermographs being used. The degree of fluctuation, as shown by the data in the tables, gave a minimum difference of 10° F. between the warm and cool greenhouses.

No attempt was made to control the humidity of the houses, and quite a wide range was observed, varying according to the amount of sunshine and the hour of the day. In general, however, the relative humidity, as measured by wet and dry bulb thermometers, was somewhat higher in the cool house. Thus evaporation was greater in the warm atmosphere. The average possible hours of sunlight

and the maximum and minimum daily temperatures for growth experiments carried on during the summer in the garden were secured from the Government Meteorological Station located on the campus of the University of Chicago.

B. CHEMICAL METHODS.—Microchemical tests were made on the germinating seedlings. The methods used were those of ECKERSON (6). The fresh tissues were sectioned and immediately tested for fats, reducing sugars, insoluble protein, and amino acids. The methods followed in the macrochemical analyses in general were those of KOCH (15). It was found necessary, however, to introduce certain modifications for plant tissue.

1. *Sampling.*—The plants were sampled at 7:30 P.M. The roots were severed and discarded and the remainder of the plants ground through a Nixtamel mill. Moisture samples were weighed out in duplicate in tared moisture dishes, care being taken to secure as homogeneous a mixture of the pulp as possible. Whenever the size of the sample permitted it was divided into two portions, and each placed in a 250 cc. tared Erlenmeyer flask. To each sample 0.5 gm. of calcium carbonate was added, and enough 95 per cent redistilled alcohol to bring the concentration to 80 per cent of alcohol. Then the samples were boiled for 15 minutes. Finally, the sample flasks were tightly corked, using corks covered with lead foil.

2. *Extraction.*—KOCH's method was used with a modification in the case of the water extraction. Here 1000 cc. of water was added to the dry and finely ground material from the ether extraction, and the mixture allowed to extract on the steam bath at 90° C. for 12 hours. By this modification quantitative losses of material were avoided. At the completion of the final alcohol extraction two fractions (one insoluble and the other soluble) were obtained.

3. *Separation.*—The soluble fraction contained much chlorophyll and some lipoid material. These were separated from the soluble nitrogen and carbohydrate compounds by shaking the liquid with several amounts of anhydrous ether. By the addition of the ether to the liquid and then diluting with water a clear separation was obtained. Any tendency to emulsify was prevented by a few additional drops of alcohol. The lipoid fraction, containing the chlorophyll, was drawn off and discarded. This fraction contained small

amounts of water in solution, and when analyzed for reducing substances gave amounts which were considered negligible.

4. *Estimation.*—The water and alcohol fraction which remained after the separation with ether was concentrated in vacuo at 70° C., and with the vacuum gauge indicating 20 inches, to a 500 cc. volume. Of this, a 200 cc. aliquot was used for the determination of reducing substances. The remainder was kept in reserve, and from it determinations of amino acids and soluble nitrogen were made as desired.

5. *Reducing substances.*—The 200 cc. aliquot was treated with neutral lead acetate, filtered, and the excess lead removed by the addition of potassium oxalate. On filtering again the filtrate and washings were made up to 500 cc. volume, and 50 cc. aliquots used for the determination of reducing substances. The SHAFFER-HARTMAN (**21**) iodometric method for the determination of small amounts of sugar was used in all carbohydrate determinations. All determinations were made in duplicate or triplicate.

6. *Total reducing substances after hydrolysis.*—An aliquot of 50 cc. of the deleaded extract was poured into a 110 cc. sugar flask and 10 cc. of concentrated hydrochloric acid added. The solution was allowed to stand at room temperature for 18 hours; then it was made up to volume and 50 cc. duplicate portions estimated for sugars.

7. *Amino nitrogen.*—Determinations were made on the liquid obtained from the ether separation, using the micro Van Slyke apparatus. The volume of the sample used was 2 cc. and the time of reaction five minutes.

8. *Nitrate nitrogen.*—The method suggested by STROWD (**22**) was used in the determination of nitrate nitrogen. In order to test the accuracy of this method when used with plant extracts a series of determinations was made. Varying amounts of potassium nitrate were added to 10 cc. portions of the extract from the ether separation, and the following results were obtained:

Potassium nitrate added in gm.	Nitrate nitrogen recovered in percentage
0.01	91.2
0.05	94.9
0.10	95.2
0.10	93.1

On further trial it was found that the addition of asparagine to the extract introduced a large error, an observation also noted by BURRELL and PHILLIPS (3); therefore, in order to determine the amounts of ammonia and amid nitrogen present in the extract, PHILLIP'S method (19) was employed. Several extracts were used and a volume of 10 cc. in each case.

Number of extract	Ammonia nitrogen (mg.)	Amid nitrogen (mg.)
1	0.14	0.13
2	0.01	0.15
3	0.05	0.02

Thus, since no ammonia and amid nitrogen determinations were made on all the extracts, the results given as nitrate nitrogen cannot be considered as within the limits of error.

9. *Total nitrogen.*—The Kjeldahl method with the nitrate modification (18) was used, and the determinations were made on the dry moisture samples.

10. *Total insoluble nitrogen.*—Aliquots of the dry insoluble residue remaining after the final extraction were analyzed for nitrogen by the Kjeldahl-Gunning-Arnold method, using 0.7–2 gm. of the finely ground material.

11. *Total soluble nitrogen.*—The difference between the total nitrogen and the total insoluble nitrogen was considered as expressing the total soluble nitrogen.

12. *Total hydrolyzable polysaccharides.*—Direct acid hydrolysis was applied to 2.5–3 gm. of the dry insoluble extracted portion (18). All carbohydrates were expressed as invert sugar.

During the course of the analyses it became necessary to transport part of the samples from Chicago to Yonkers, New York. These samples were washed quantitatively, using small portions of alcohol, into pint jars having aluminum screw tops. A cork washer was placed in the screw top of each jar and melted paraffin poured on it until the cork became impregnated. This was allowed to partially solidify and then the top was screwed on the jar, producing a seal which quite adequately prevented loss of extract.

Experimentation

GROWTH.—*Xanthium* plants were grown under varying combinations of temperature and length of day. Observations were made

to determine the first indications of staminate flower buds, and the time from planting to flower formation calculated. The first staminate flower cluster appears in the apical region of the stem, and when the tetrad stage is reached, small protuberances are plainly visible under a dissecting microscope. In every case an average of observations from several plants was calculated, and by this means individual variation was minimized.

TABLE I

HIGH-TEMPERATURE SHORT-DAY CONDITIONS

EXPERIMENT NO.	VEGETATIVE STAGE	AVERAGE POSSIBLE SUNLIGHT IN HOURS	AVERAGE WEEKLY TEMPERATURES	
			Maximum °F.	Minimum °F.
III.....	Jan. 23–Feb. 7 (15 days)	9.7–10.4 (Average 10)	77.2 78.8	68.2 71.7
IV.....	Feb. 24–Mar. 10 (15 days)	10.0–11.9 (Average 11.5)	79.7 74.0	68.2 68.5
VII.....	Mar. 12–26 (14 days)	11.8–12.4 (Average 12.1)	81.8 77.5	67.7 69.8
VIII.....	Mar. 22–Apr. 5 (14 days)	12.2–13.1 (Average 12.6)	78.6 76.7	65.8 70.6
XX.....	May 20–June 2 (13 days)	10	83.7 90.5	70.2 70.2
XXIII.....	June 11–24 (13 days)	10	87.1 95.0	70.2 74.5
XXIV.....	July 2–14 (12 days)	10	90.5 92.7	72.5 74.5

High-temperature short-day plants.—These were grown in the greenhouse during the months of November 1923 to March 1924 inclusive. Germination was observed from three to five days after planting. Table I gives the environmental conditions and the results of several experiments. In the cases of the final three experiments, the light duration was controlled accurately by covering the plants at the end of ten hours of daylight. Under these conditions the time of distinctive vegetative activity was very short. As a result, the plants had an average height of 11.5 cm. when measured from the soil level to the staminate bud cluster. When

allowed to set fruit a very small number of poorly developed burs resulted.

High-temperature long-day plants.—The following two experiments were carried out in the greenhouse after the natural day length had increased. In height the plants in Experiment XV averaged 25 cm. The increased day length resulted in a lengthening of the vegetative period.

TABLE II

HIGH-TEMPERATURE LONG-DAY CONDITIONS

EXPERIMENT NO.	VEGETATIVE STAGE	AVERAGE POSSIBLE SUNLIGHT IN HOURS	AVERAGE WEEKLY TEMPERATURES	
			Maximum °F.	Minimum °F.
XII.....	Apr. 15–May 7 (22 days)	13.4–14.3 (average 13.8)	81.5	67.5
			83.7	70.2
			83.7	67.0
XV.....	Apr. 29–June 15 (47 days)	14.0–15.2 (average 14.6)	83.7	67.5
			84.5	70.0
			83.7	70.1
			83.5	67.7
			89.7	71.7
			84.7	70.2
			86.1	70.2

In addition to these three experiments, seeds were planted in shallow 4-inch pots and exposed to 24-hour illumination in the specially constructed and conditioned room used for such experiments, at the Boyce Thompson Institute. The plants were exposed to very uniform conditions of temperature and humidity, the temperature rarely showing a variance of one degree above or below 78° F., and the humidity being maintained at 86 per cent. The seeds were planted October 8, 1924; germination was observed October 11; and on November 19, when the experiment was discontinued, no signs of staminate flower buds could be found. Seven plants had reached an average height of 40.5 cm. These plants thus were still actively vegetative forty-two days after planting. Low-temperature short-day plants were started from seed November 20, 1923; germination was observed on November 26; and staminate flower buds noted on March 15, 1924. This made a total of 116 days during which the plants were actively vegetative. The average height of the plants

on March 15 was 51 cm., and cross-sections of their stems showed the presence of much strengthening tissue. Fig. 1 indicates the conditions of temperature and possible sunlight during that period. The length of the vegetative stage in these plants was comparable with that of the low-temperature long-day plants.

Low-temperature long-day plants.—The following three experiments give an indication of the reaction of *Xanthium* to this combination of environmental factors.

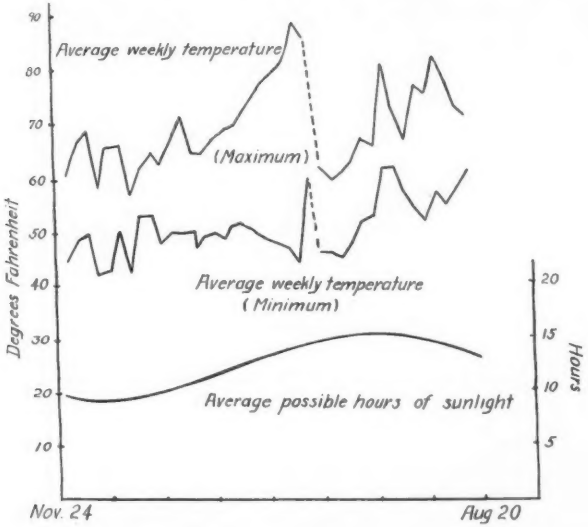

FIG. 1.—Temperature and average possible hours of sunlight from November 24, 1923 to August 20, 1924.

Experiment III.—Seeds were planted in the warm house on January 23, 1924; transferred to the cool house on February 2, and finally transplanted in the garden on May 2. Staminate flower buds were observed on August 7, thus making a total of 197 days for the active vegetative stage.

Experiment XII.—Seeds were planted in the warm house on April 15, and the plants transplanted in the garden May 2. Stami-

nate flower buds were observed on August 7, making a total of 114 days for active vegetation.

Experiment XXI.—Seeds were planted in the garden on May 20, and staminate flower buds were observed August 20, making a total of 92 days for the vegetative stage.

Fig. 1 gives a record of the temperature maxima and minima, and also the average possible hours of sunlight during the portion of the year covered by the experiments.

Analyses[1]

Following the growth experiments, an attempt was made to secure some information as to the metabolic conditions within the

TABLE III: SERIES A

HIGH-TEMPERATURE SHORT-DAY PLANTS; PERCENTAGE DRY WEIGHT BASIS

TIME IN DAYS	REDUCING SUBSTANCES	HYDROLYZABLE POLYSACCHARIDES
7	0.34	8.78
8	0.41	7.89
9	0.59	9.10
10	0.54	9.88
11	0.93	10.08
12	1.06	10.31
13	0.95	10.44
14	0.99	12.97
15	.....	14.14

plants as they approached flowering, and especially when they were subjected to conditions of temperature and day length, which were distinctly opposed to each other.

SERIES A.—High-temperature short-day plants were grown in the warm greenhouse in large shallow boxes. The day length was controlled to 10 hours. The temperature data are given in table I, Experiment XXIV. Sampling was begun on the seventh day after planting, and the plants were sampled daily until the sixteenth day. Staminate flower buds were noted on the twelfth day. For each

[1] The major portion of the analyses was made at the Boyce Thompson Institute for Plant Research, Yonkers, New York.

analytical sample 150–200 plants were used. On the twelfth day the plants averaged 11.5 cm. in height, and cross-sections of the stems taken near the ground gave an average diameter of 0.4 cm. The analytical results are given in tables V, VI, and VII. Distinct increases in reducing substances, hydrolyzable polysaccharides, and

TABLE IV: SERIES A

HIGH-TEMPERATURE SHORT-DAY PLANTS; PERCENTAGE DRY WEIGHT BASIS

TIME IN DAYS	TOTAL NITROGEN	SOLUBLE NITROGEN	INSOLUBLE NITROGEN	AMINO NITROGEN
7	7.00	2.62	4.38	1.81
8	7.10	3.78	3.32	1.59
9	6.68	2.48	4.20	1.00
10	6.55	2.65	4.00	1.07
11	6.58	2.56	4.02	1.09
12	5.55	1.25	4.30	1.16
13	5.58	1.38	4.20	1.36
14	5.31	1.64	3.67	1.36
15	4.70	1.22	3.60	.....
16	4.87	1.27	3.48	.....

TABLE V: SERIES A

MISCELLANEOUS DATA: HIGH-TEMPERATURE SHORT-DAY PLANTS

TIME IN DAYS	MOISTURE PERCENTAGE	SOLUBLE C/N RATIO	TOTAL C/N RATIO
7	93.2	0.13	1.30
8	95.5	0.11	1.16
9	90.5	0.23	1.45
10	92.8	0.20	1.59
11	91.7	0.36	1.67
12	93.3	0.84	2.04
13	92.9	0.68	2.04
14	91.3	0.60	2.62
15	90.3	.....	3.00

amino acids were found, while soluble nitrogen forms decreased. Both the total and the soluble carbohydrate-nitrogen ratios increased as the plants became reproductive.

SERIES B.—Plants were grown in the garden under low-temperature long-day conditions. The environmental conditions of temperature and day length are represented in fig. 1, and are those connected with Experiment XXI. Sampling was begun on July 25,

and samples were taken weekly until August 20. Staminate flower buds were observed on August 13. At the time of final sampling

TABLE VI: SERIES B

LOW-TEMPERATURE LONG-DAY PLANTS; ANALYSES OF UPPER PARTS; PERCENTAGE DRY WEIGHT BASIS

TIME IN WEEKS	REDUCING SUBSTANCES			REDUCING SUBSTANCES AFTER HYDROLYSIS			HYDROLYZABLE POLYSACCHARIDES		
	I	II	Average	I	II	Average	I	II	Average
9	1.45	.....	.....	1.98	.....	.....	12.21	.....	.....
10	1.38	1.50	1.44	1.91	1.73	1.87	17.51	16.28	16.89
11	0.64	1.09	0.86	0.94	0.96	0.95	14.26	14.41	14.33
12	2.50	2.61	2.55	3.82	3.92	3.87	19.56	19.75	19.65
13	4.57	2.34	3.45	5.43	3.28	4.35	22.40	28.27	20.33

TABLE VII: SERIES B

LOW-TEMPERATURE LONG-DAY PLANTS; ANALYSES OF UPPER PARTS; PERCENTAGE DRY WEIGHT BASIS

TIME IN WEEKS	TOTAL NITROGEN	INSOLUBLE NITROGEN			SOLUBLE NITROGEN			AMINO NITROGEN			NITRATE NITROGEN		
9	4.82	4.52	....	....	0.30	....	....	0.02	....	....	....	....	....
10	4.81	4.53	4.40	4.46	0.35	....	....	0.06	0.09	0.07	0.12	0.16	0.14
11	4.81	4.29	4.72	4.50	0.27	0.36	0.31	0.08	0.13	0.10	0.29	0.29	0.29
12	4.98	4.35	4.02	4.68	0.20	0.35	0.27	0.13	0.12	0.13	0.24	0.14	0.19
13	4.54	4.22	3.97	4.09	0.45	....	....	0.15	0.14	0.15	0.15	0.12	0.14

TABLE VIII: SERIES B

LOW-TEMPERATURE LONG-DAY PLANTS; ANALYSES OF LOWER PARTS; PERCENTAGE DRY WEIGHT BASIS

TIME IN WEEKS	REDUCING SUBSTANCES			REDUCING SUBSTANCES AFTER HYDROLYSIS			HYDROLYZABLE POLYSACCHARIDES		
	I	II	Average	I	II	Average	I	II	Average
9	1.82	1.83	1.82	2.49	2.76	2.62	5.01	5.14	5.07
10	1.20	1.56	1.38	3.65	3.46	3.55	5.27	7.54	6.40
11	1.98	1.13	1.55	1.90	1.21	1.55	7.75	7.91	7.83
12	2.72	0.64	1.68	4.24	1.57	2.90	8.36	11.90	10.13
13	2.25	6.36	4.30	4.09	9.00	6.54	22.12	19.03	20.57

the plants averaged 94 cm. in height, and had an average stem diameter of 2.5 cm. when sectioned at the first node above the ground. The plants of this series were divided into two portions

for analysis, as the amount of material was sufficient for both duplicate samples and for analyses of tops and lower portions. The

TABLE IX: SERIES B

LOW-TEMPERATURE LONG-DAY PLANTS; ANALYSES OF LOWER PARTS; PERCENTAGE DRY WEIGHT BASIS

TIME IN WEEKS	TOTAL NITROGEN	INSOLUBLE NITROGEN			SOLUBLE NITROGEN			AMINO NITROGEN			NITRATE NITROGEN		
		I	II	Average	I	II	Average	I	II	Average	I	II	Average
9	3.13	1.18	1.42	1.30	1.95	1.80	1.87	0.06	0.06	0.06	0.10	0.21	0.15
10	3.41	1.66	1.60	1.63	1.75	1.81	1.78	0.13	0.06	0.09	0.53	0.75	0.64
11	2.50	....	1.04	....	....	1.46	....	0.05	0.10	0.07	0.64	0.53	0.58
12	2.82	1.07	1.41	1.24	1.75	1.41	1.58	0.11	0.10	0.11	0.65	0.42	0.53
13	2.13	1.11	1.09	1.10	1.02	1.04	1.03	0.73	0.26	0.49	0.10	0.11	0.10

TABLE X: SERIES B

LOW-TEMPERATURE LONG-DAY PLANTS; AVERAGED RESULTS OF TABLES VI AND VIII TO COVER ENTIRE PLANTS; PERCENTAGE DRY WEIGHT BASIS

TIME IN WEEKS	REDUCING SUBSTANCES	TOTAL REDUCING SUBSTANCES AFTER HYDROLYSIS	HYDROLYZABLE POLYSACCHARIDES
9	1.63	2.30	8.64
10	1.41	2.71	11.64
11	1.20	2.25	11.08
12	2.11	3.38	14.89
13	3.87	5.44	20.45

TABLE XI: SERIES B

LOW-TEMPERATURE LONG-DAY PLANTS; AVERAGED RESULTS OF TABLES VII AND IX TO COVER ENTIRE PLANTS; PERCENTAGE DRY WEIGHT BASIS

TIME IN WEEKS	TOTAL NITROGEN	INSOLUBLE NITROGEN	SOLUBLE NITROGEN	AMINO NITROGEN	NITRATE NITROGEN
9	3.97	2.91	1.08	0.04	0.15
10	4.11	3.04	1.06	0.08	0.39
11	3.65	2.77	0.88	0.08	0.43
12	3.90	2.96	0.92	0.12	0.36
13	3.33	2.59	0.74	0.32	0.12

point of division was chosen as the fifth node from the ground, the roots being discarded. The analytical results are given in tables VI–XII. These results show the presence of greater quantities of

reducing substances and total reducing substances after hydrolysis in the lower parts of the plants, while insoluble nitrogen forms are high in amount in the tops. Soluble nitrogen compounds are highest in the lower portions however. When the entire plant is considered, as in tables XI and XII, it is seen that carbohydrate forms increased in amount, while soluble nitrogen forms showed a distinct falling off.

TABLE XII: SERIES B

MISCELLANEOUS DATA: LOW-TEMPERATURE LONG-DAY PLANTS

TIME IN WEEKS	MOISTURE PERCENTAGE	SOLUBLE C/N RATIO	TOTAL C/N RATIO
9.....	86.86	1.50	2.75
10.....	86.47	1.33	3.17
11.....	83.13	1.36	3.36
12.....	84.80	2.29	4.36
13.....	84.58	5.22	7.30

In order to allow comparison between the ratios in the two series, the total reducing substances after hydrolysis as estimated in Series B were not included in the calculations.

Seedling stages

A study of the effect of temperature on metabolism of *Xanthium* during the seedling stage was made. Seeds were germinated at two widely differing temperatures and analyses made.

MICROCHEMICAL TESTS.—Seeds were germinated in Petri dishes kept at 95° and 68° F. on moistened filter paper. Microchemical tests were made daily for the presence of fats, carbohydrates, protein, and amino acids in both cotyledons and hypocotyls. The tests were discontinued when Sudan III no longer gave a positive test for fats in the cotyledons. No tests for starch or glucose were obtained in the dry seed, although an amorphous precipitate resembling copper oxide was obtained with the Flückiger test. After twenty-four hours' germination at the higher temperature this reduction became very marked, and the presence of glycerine was demonstrated by using the acrolein test. It is possible, therefore, that this reduction was caused by intermediate products in the process of transformation from fats to carbohydrates. At the lower

temperature a marked development of pigment and a definite accumulation of reducing carbohydrates took place in the first few centimeters of the hypocotyl. These results were in direct contrast with the higher temperature seedlings, where growth was very rapid and the accumulation of carbohydrates was prevented. When the lower temperature seedlings were allowed to grow, they developed all the characteristics of the low temperature plants. An estimation of the varying proportions of metabolic materials in cotyledons and hypocotyls is given in table XIII.

TABLE XIII

MICROCHEMICAL ANALYSES OF SEEDLINGS

TIME OF GERMINATION IN HOURS	FATS		CARBOHYDRATES				PROTEINS					
	Sudan III		Flückiger test		Osazone test		IKI test		Millon's test		Xanthoproteic test	
	95° F.	68° F.	95° F.	68° F.	95° F.	68° F.	95° F.	68° F.	95° F.	68° F.	95° F.	68° F.
24	***	***	.....	.....	.....	.....	***	***	***	***	***	***
48	**	***	.....	**	.....	**	***	***	***	***	***	***
80	*	***	*	**	.....	***	**	***	**	***	***	***
96	*	***	**	**	*	***	**	***	**	***	**	***
120	.....	**	**	***	**	***	**	***	**	***	**	***

MACROCHEMICAL TESTS.—*Xanthium* seeds were germinated in constant temperature ovens at 90° and 72° F., on filter paper kept moist by keeping it in contact with wet sand. Sampling was begun when the hypocotyl radicles were 3 inches in length, and 500–1000 seedlings composed each sample. The hypocotyl radicles were severed from the cotyledons and analyzed separately. The material was frozen, ground, and preserved as already described in the case of the plant samples. All analytical results are the averages of at least two determinations. The amount of material was too small to allow the use of duplicate samples. From the results given in tables XIV and XV, the seedlings grown at the lower temperature gave on analysis much larger amounts of total reducing substances after hydrolysis, hydrolyzable polysaccharides and amino acids, results which agree with those already indicated by microchemical tests.

DICKSON, ECKERSON, and LINK (4), working with wheat seedlings, found that at low soil temperatures the rate of starch hydroly-

sis is more rapid than that of protein food reserves. This makes the young plants practically carbohydrate-high, and as a result they have cell walls thicker and more resistant to the invasion of fungus

TABLE XIV

EFFECT OF TEMPERATURE ON GERMINATION OF XANTHIUM SEEDLINGS

TEMPERATURE (°F.)	REDUCING SUBSTANCES	TOTAL REDUCING SUBSTANCES	HYDROLYZABLE POLYSACCHARIDES
	Cotyledons		
90	0.06	2.28	0.13
72	0.64	4.90	0.14
	Hypocotyls		
90	9.55	12.01	2.34
72	7.51	16.63	4.29

TABLE XV

EFFECT OF TEMPERATURE ON GERMINATION OF XANTHIUM SEEDLINGS

TEMPERATURE (°F.)	SOLUBLE NITROGEN	INSOLUBLE NITROGEN	AMINO NITROGEN
	Cotyledons		
90	2.75	2.68	0.90
72	2.11	4.07	1.57
	Hypocotyls		
90	4.25	6.98	1.71
72	4.41	3.13	2.11

hyphae. In the case of *Xanthium* the lower temperatures bring about an earlier hydrolysis of the carbohydrate forming reserves, and a slower hydrolysis of the protein reserves.

Discussion

Recently much stress has been placed on relative day length as one of the most important formative factors to which a plant is subjected by its environment. This phenomenon, however, is only one of many which influence a plant during its growth period, and therefore humidity, nutrient supply, and temperature must greatly

modify its importance as a formative factor. The great complexity of environmental combinations in nature would lead us to believe that, while at one time one specific factor may be the cause of the inhibition or acceleration of a certain formative change, under a

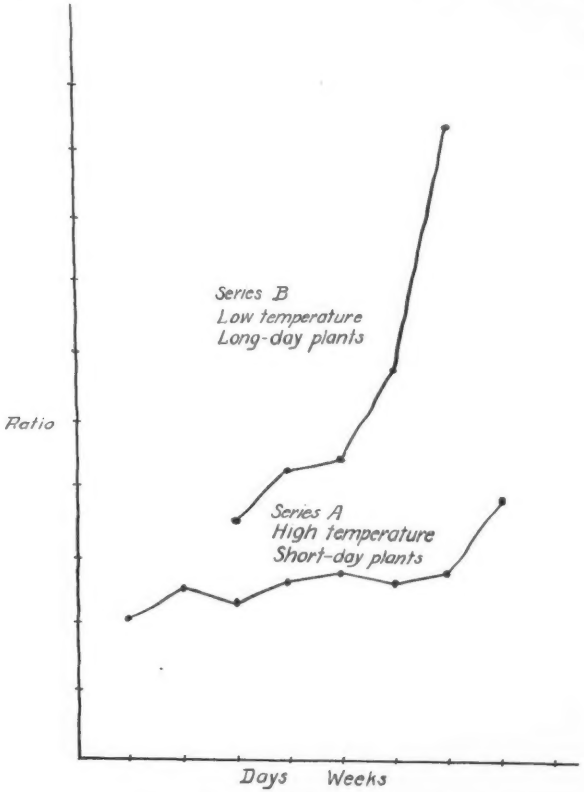

FIG. 2.—Ratio of total carbohydrates to total nitrogen

different set of conditions another factor may assume the same rôle. BLACKMAN (2) has emphasized the theory of limiting factors which control photosynthesis, and among his factors he has given temperature a prominent place. In a similar manner relative day length may possibly act as a deciding factor under certain combinations of

conditions, and thus inhibit or accelerate vegetative activity. Evidence is also gradually accumulating to show that the length of the vigorously vegetative period of certain plants is affected to a like degree by temperature and day length. Such seems to be the case with *Xanthium*. Further experimentation under more accurately controlled environmental conditions may be expected to show that, even as specific day lengths are limiting for vegetative activity with certain plants, so, given certain environmental combinations, specific temperatures may be found to substitute for relative day length in the development of flower primordia.

It is quite generally accepted that a change in the growth habit, such as that from vegetation to reproduction, is accompanied by changes in the metabolic equilibria within the plant. At present,

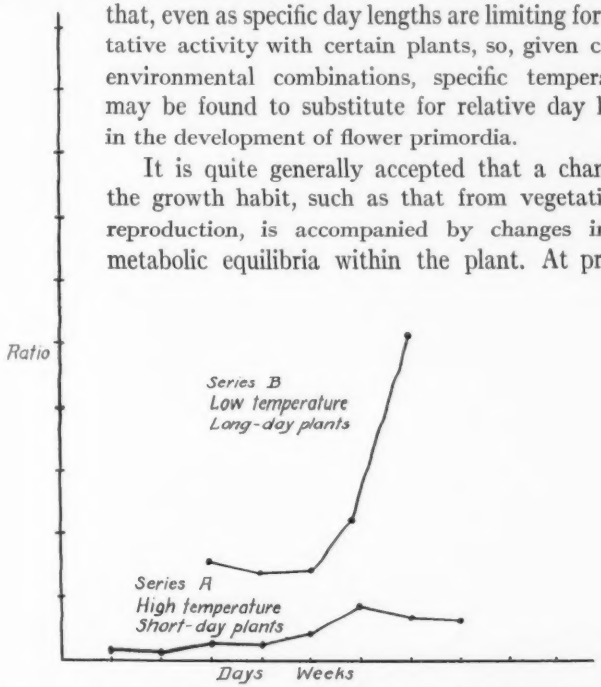

FIG. 3.—Ratio of soluble carbohydrates to soluble nitrogen

the only means of studying these changes is by the analytical method. Thus, if a series of analytical results can be obtained which shows a decided tendency in any one direction, some criterion of the metabolic state may be suggested. In *Xanthium*, comparisons between total carbohydrates and total nitrogen (fig. 2), and soluble carbohydrates and soluble nitrogen (fig. 3) show the ratios to be distinctly ascending as flower primordia are formed under the

influence of both sets of conditions. This is in accord with the work of KRAUS and KRAYBILL and others. Recently NIGHTINGALE has stressed the ratio of carbohydrates to insoluble nitrogen as being more indicative of metabolic conditions. Following his suggestion, the ratios of total carbohydrates to insoluble nitrogen (fig. 4), and

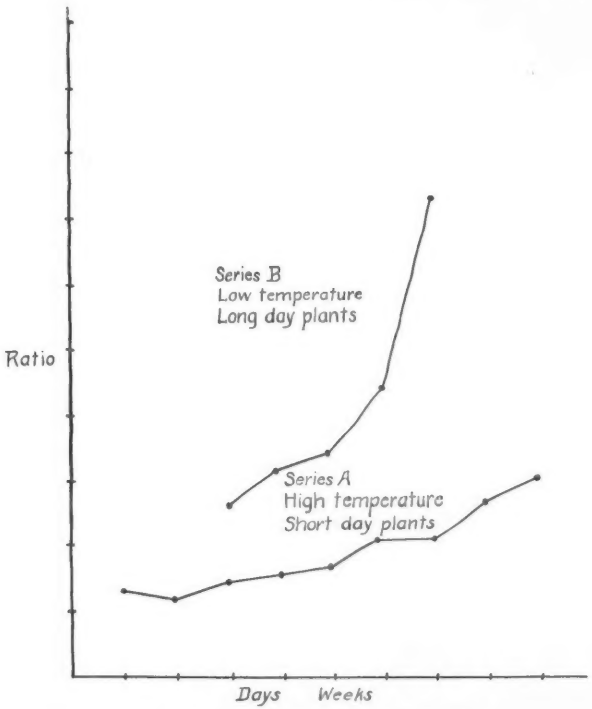

FIG. 4.—Ratio of total carbohydrates to insoluble nitrogen

soluble carbohydrates to insoluble nitrogen (fig. 5) are given for *Xanthium*.

The careful study of material grown under a wider range of conditions is considered desirable before any conclusion as to the significance of such comparisons can be of value. It should be noted that the results given by Series B cover much shorter portions of

the life of the plant than do those of Series A. If weeks and days are equated, the ninth week corresponds closely to the ninth day, and so the actual portion of the history of the plant covered by both might be considered as being comparable. While it must be borne in mind that no single ratio can at present be assigned a causative rôle in the formation of flower primordia, it is worthy of note that in the two series ascending carbohydrate nitrogen ratios were noted, even though the total lengths of the vegetative periods contrasted greatly. These comparable results justify the conclusion that while *Xanthium* is very suceptible to temperature and relative day length, when reproduction does begin the same sort of metabolic conditions occur when the interrelation of carbohydrate and nitrogen compounds are considered.

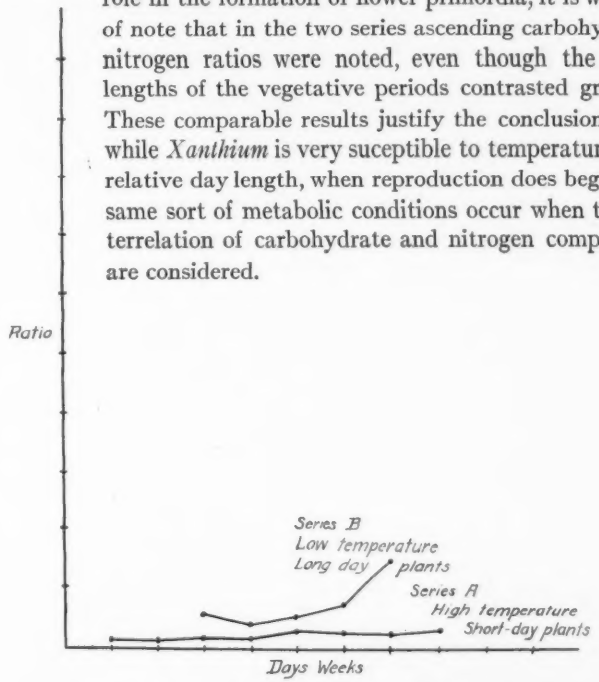

FIG. 5.—Ratio of soluble carbohydrates to insoluble nitrogen

By some, conditions during the germinative stage have been considered as important from the standpoint of their effect on the after history of the plant. It has been suggested by WALSTER that high temperature, coupled with high nitrogen supply, shifts the metabolic equilibria toward excessive vegetation, and inhibits the tendency toward normal vegetation. This must be counteracted by some other factor during the vegetative stage if reproduction is to

be expected. The analytical results with *Xanthium* seedlings seem to throw some light on such a tendency. The low temperature seedlings contain greater amounts of higher carbohydrate compounds, thus showing a tendency toward the formation of mechanical and other tissues found in low temperature plants. This accumulation of carbohydrate compounds was no doubt facilitated by the low temperature conditions which resulted in a lower respiratory rate. There can be no doubt but that the strongly vegetative characteristics of the low temperature plants received their start by low temperature conditions during germination and early seedling stages. It is doubtful, however, whether a tendency toward vegetation or reproduction due to early temperature conditions can account for the marked reactions to both temperature and day length during the later stages of the actively vegetative period of *Xanthium*.

Summary

1. Growth experiments and chemical analyses were made with plants of *Xanthium pennsylvanicum*, grown under known conditions of temperature and relative day length.

2. Temperature was found to be a determining factor in influencing the time of flower primordia formation. This temperature effect, however, was closely associated with a response to relative day length.

3. The interrelation of day length and temperature was shown to be as follows: (1) high-temperature short-day plants gave indications of flowering 12–15 days after planting; (2) high-temperature long-day plants were found to flower 47 days after planting; (3) low-temperature short-day plants vegetated actively for 116 days before staminate flower buds were produced; (4) low-temperature long-day plants remained actively vegetative for a minimum of 92 days.

4. Chemical analyses of high-temperature short-day and low-temperature long-day plants resulted in ascending carbohydrate nitrogen ratios in both cases as the plants approached flower primordia formation. A marked difference in the magnitude of the ratios was noted.

5. Chemical analyses of seedlings germinated under high and

low temperature conditions showed a marked accumulation of reducing sugars and condensed sugar forms in the low temperature hypocotyl radicles. This accumulation suggests a physiological predetermination influencing the initial stages of growth.

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AGRICULTURAL EXPERIMENT STATION
KINGSTON, R.I.

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STUDIES IN THE GENUS BIDENS. VII

CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY 344

EARL EDWARD SHERFF

(WITH PLATES I–IV)

Bidens Moorei, sp. nov. (Pl. 1)—Herba perennis, glabra, 3–5 dm. alta, caule adscendente et ramoso; ramis plus minusve glaucescentibus, monocephalicis, gracilibus, supra nudis, infra foliis parvulis foliosis. Folia sessilia, lanceolata vel cuneato-oblanceolata, integra vel versus apicem irregulariter dentata, carnosa, 1–6 cm. longa. Capitula terminalia, longe pedunculata, ligulata, 4–5 cm. lata. Involucrum squamis duplici serie dispositis; exterioribus circiter 8, ovatis vel ovato-lanceolatis, 6–8 mm. longis; interioribus lanceolatis, membranaceis, striatis, 1.2–1.4 cm. longis. Flores ligulati circiter 8, flavidi, ligula lineares, striati, apice dentati 2–2.6 cm. longi. Achaenia linearia, plana vel subtetragona, adscendenti-ciliata et -hispida, corpore 0.8–1.5 cm. longa et 1–1.2 mm. lata, bi- (saepe imperfecte tri- vel quadri-) aristata aristis retrorsum hamosis, usque ad 5 mm. longis.

John Gossweiler 3339, in woods, Angola, April, 1906 (type in Herb. Brit. Mus.); *idem* 2467, in sandy, herb-grown woods, January 5, 1906; *H. Baum* (Reise nach Südwest-Africa) 708, at altitude of 1275 m., sandy ground among low bushes, along the Longa River ("oberhalb des Quiriri," "oberhalb Ninescra"), Angola, February 5, 1900 (Herb. Berl., Herb. Brit. Mus.).

O. HOFFMANN, in his original determination of BAUM's plant just cited, treated it as a new species. Whether he did so because at that time he was unfamiliar with *Bidens andongensis* Hiern, or because, although familiar with HIERN's species, he felt BAUM's plant to be distinct, I am unable to say. However, he later (Kunene-Sambesi Exped. 420. 1903) referred the BAUM specimen to *Bidens andongensis* Hiern. Since the main differences lay in the size and shape of the involucres, also the number and shape and proportionate size of the exterior involucral bracts, one might indeed have suspected that BAUM had collected merely an atypical and less robust form of *B. andongensis*. The various specimens sent in more recently by GOSSWEILER to the Herbarium of the British Museum, however, show similar peculiarities as to these characters, thus strengthening the belief that we have to do with a distinct species.

The species is here named in honor of SPENCER L. MOORE of the Herbarium of the British Museum of Natural History, who has done much admirable work upon the African species of *Bidens*, and who, independently of myself, had likewise interpreted the above GOSSWEILER plants as typifying a new species.

BIDENS MOOREI **verrucosa,** var. nov.—A specie differt achaeniis verrucatis; his plerumque 6–8 aristatis, saepe praeterea 4–10 laevibus acutis aristulis coronatis.

John Gossweiler 3021, Angola, April, 1906 (type in Herb. Brit. Mus.).

A form so peculiar in fruit characters that it is perhaps best treated for the present as a variety. Various considerations indicate no basis for regarding it as a separate species. The achenes are minutely warty and 5–8-aristate (commonly with 3 long aristae and 2–5 short ones, with frequently 4–10 additional rudimentary, smooth, sharp aristae completing a crown). The variety is seen to be comparable, in its relation to the species proper, with the var. *verrucifera* Moore of *Bidens crocea* Welw. In its large number of aristae it makes a singular approach to *Ericentrodea mirabilis* (Sherff) Blake and Sherff, a plant that differs widely, however, in other respects.[1]

Ericentrodea Blake and Sherff, gen. nov.—Fructices (et herbae?) scandentes, foliis oppositis, petiolatis, ternatis vel biternatim divisis, coriaceis; capitulis cymoso-paniculatis, discoideis vel radiatis, flavis; involucro duplici ut in Bidente, bracteis exterioribus parvis, herbaceis, interioribus submembranaceis, lineatis; receptaculo subplano; paleis subplanis, membranaceis, lineatis; ligulis (si praesentibus) pistillatis, fertilibus; disci floribus hermaphroditis, corollis tubulosis, tubo tenui, gutture infundibuliformi, limbo breviter 5-denticulato; antherarum basibus cordato-sagittatis et appendicibus ovatis terminalibus; stylo exserto, ramis brevibus, ramorum appendicibus triangularibus, acuminatis, papillatis; achaeniis valde obcompressis, corpore obovato manifeste vel obsolete 2-alato, ad marginem lobulatum grosse ciliato, ad apicem in collare vel cervicem brevem angustato; aristis fragilibus, circ. 6–15 (3–"8" supra utrumque achaeniorum angulorum et inter se plerumque basi plus minusve connatis, utroque achaeniorum laterum interdum 2 vel 3 aristis brevioribus intermediis armato.

Type species *Narvalina corazonensis* Hieron.

BIDENS CHINENSIS (L.) Willd. var. ABYSSINICA (Schz. Bip.) O. E. Schulz, Engler Bot. Jahrb. **50** (Supplem.) : 180. 1914; *B. abyssinica* Schz. Bip., Walpers Repert. **6**:167. 1846–1847: *B. abyssinica* var. *quadriaristata* Hochst. *ex* Schweinfurth Beitr. Fl. Aethiop. **1**:142. 1867; *B. quadriseta* Hochst. *ex* Oliver, Fl. Trop. Afr. **3**:393. 1877: *B. abyssinica* var. *incisifolia* Hochst. *ex* Oliv. *l.c.;*

[1] *Bidens mirabilis* Sherff, BOT. GAZ. **61**:496. 1916.—In a recent paper (Jour. Wash. Acad. Sci. **13**:104. 1923), S. F. BLAKE and I have joined in creating the new generic name *Ericentrodea* for this and two other species. The generic description, there given in English, is here repeated in Latin to satisfy the requirements of the Vienna Code of Nomenclature:

B. lasiocarpa O. E. Schulz, Engler Bot. Jahrb. **50** (Supplem.):185. 1914.

Some of SCHIMPER'S original specimens, on which were founded the names *Bidens abyssinica*, *B. abyssinica* var. *quadriaristata*, and *B. quadriseta*, are densely hairy forms with tripartite leaves and conspicuously large fruiting heads. In leaf characters they might be confused with *B. pilosa* L.; their achenes and involucral bracts, however, are very distinct. Some cotypes of "*B. abyssinica*" (for example, in Herb. Brit. Mus.) show leaves more incisely toothed or lobed and approaching more or less clearly those of *B. chinensis* (L.) Willd. A diminutive specimen collected by SCHWEINFURTH and RIVA (no. 804, in Herb. Boiss.) has the leaves glabrous and bipinnate as in *B. bipinnata* L. The fruit characters sometimes seem much too distinctive to warrant giving "*B. abyssinica*" a varietal rank under *B. chinensis* as proposed by O. E. SCHULZ, but the great number of intergradations observed in various herbarium specimens appears to compel such a course. It may be observed, however, that the variety is to be separated from the species not so much by its hairiness, which SCHULZ gives as the distinguishing character, as by its longer achenes, the outer ones often densely setose.

The varietal name *incisifolia* was given originally to specimens of *Schimper* 2328, described (OLIVER, *l.c.*) as having "rather more deeply cut leaf-lobes." The authentic sheet of this number at Kew, however, marked "Fl. Afr. Trop. iii p. 393," has none of its leaves incisely toothed to a noticeable degree.

In proposing as a new species his *Bidens lasiocarpa*, SCHULZ gave emphasis (in key, *l.c.* 187) to the outer achenes being more or less recurved and commonly very densely hirtous, but this character is present equally well in the type material of the var. *abyssinica*, and seems to have been overlooked by him. Moreover, *B. lasiocarpa* has long achenes, as in the type material of the var. *abyssinica*, and, while differing in the variable character of leaf hairiness, is too closely connected by intermediate forms in the herbaria to rank as a separate species.

BIDENS GRANDIS Sherff, BOT. GAZ. **59**:309. 1915; *Coreopsis lineata* Klatt, Ann. Naturh. Hofmus. Wien **7**:103. 1892; *C. speciosa* Hiern, Cat. Welw. Pl. **1**^{III}:585. 1898.

In a previous paper (SHERFF, *l.c.*) this species was transferred from *Coreopsis* to *Bidens*, being named entirely anew because there was already the valid *Bidens speciosa* Gardner. Recently, on studying the large collections of the Berlin Herbarium, I found two sheets of KLATT'S type specimens of his *Coreopsis lineata* (*Alex von Mechow* 131, Pungo Andongo, Angola, January–April, 1879). These not only came from one of the localities where *Bidens grandis* originally was collected, but match the type material of *B. grandis* (Herb. Brit. Mus.) well. The existence of *Bidens lineata* Sherff (BOT. GAZ. **76**:84. 1923) fortunately precludes the necessity of going back to take up KLATT'S earlier published trivial name for *B. grandis*.

Bidens cylindrica, sp. nov.—Herba gracilis, erecta, 4–7 dm. alta, caule tetragono, glabro, ramoso, circ. 2–3 mm. diam. Folia petiolata petiolis tenuibus 1–5 cm. longis, petiolo adjecto principalia 5–13 cm. longa, pinnatim 3–5-partita foliolis lanceolatis vel lateralibus ovatis, membranacea, serrata dentibus acriter apiculatis, margine ciliata, faciebus glabrata vel sparsissime adpresso-pilosa. Capitula ramos tenues plerumque nudos usque ad 13 cm. longos terminantia, plerumque subradiata, ad anthesin 4–5 (rarius –10) mm. alta et 3.5–4.5 (rarius –7) mm. lata, saepe cylindrica. Involucri bracteae exteriores 6–8, lineares, versus apicem saepius angustatae, apice acutae, margine piloso-ciliatae, faciebus glabrae vel sparsim hispidae, 3–8 mm. longae et 0.3–1 mm. latae; interiores lanceolatae, apice subacutae, paulo vel interdum multo longiores. Flores ligulati rudimentarii, albidi vel rosaceo-albidi, oblongo-obovati, apice subtruncati et circ. 3-dentati. Achaenia 6–12, linearia, tetragona, atra, glabra vel exteriora saepe hispida, corpore 1.2–1.6 mm. longa et 0.5–0.8 mm. lata, bi- vel triaristata aristis moderate tenuibus retrorsum hamosis 2.5–4 mm. longis.

Specimens examined.—*Menyhart* 1110, not abundant, in shady places at St. Joseph, Boruma ("Boroma"), Northern Zambesia, Rhodesia, April, 1892 (type in Herb. Univ. Vienna); *Anon.*, cult. in Bot. Gard. Vienna *ex sem. Menyhartii* 1110 (2 sheets, Herb. Univ. Vienna); *Aug. Chevalier* 2816, along the Schari River, Tschad Lake district, Central Africa, October 26, 1899 (Herb. Berl.).

The CHEVALIER specimen listed here had been determined by O. E. SCHULZ as his *Bidens Engleri*, and in fact was cited by him for that species at the time of his original description (Engler Bot. Jahrb. **50** (Supplem.):186. 1914). Recently, however, I have been privileged to study not only SCHULZ's type of *B. Engleri* (Herb. Berl.), but also excellent sheets of duplicate material (Herb. Boiss.; Herb. Mus. Vienna, etc.). These all agree in having plants of low stature (2–3 dm. high), the leaves practically all undivided, the heads discoid; the exterior involucral bracts only about 3 or 4, spatulate, serrulate-ciliate, 1–2 mm. long; the inner bracts 2–5 times as long, often rounded at apex; the achenes all glabrous, parallel-sided through most of their length and thus *oblong*-linear, compressed, about 1 mm. wide. From this material the CHEVALIER and MENYHART specimens are seen to differ sharply as follows: Height 4–7 dm., leaves 3–5-parted, heads subradiate; the exterior involucral bracts 6–8, linear and mostly narrowed above, ciliate with slender hairs instead of with minute serrulations, 3–8 mm. long; the inner bracts mainly 1.1–2 times as long, subacute at apex; the outer achenes frequently hairy, all narrower and gradually attenuate upward, distinctly tetragonal, only 0.5–0.8 mm. wide. In my opinion the CHEVA-

LIER and MENYHART specimens are to be considered as specifically distinct from *B. Engleri*. They are named *B. cylindrica* in allusion to the shape of the flowering heads, which, in the two cultivated specimens studied, are notably cylindric.

BIDENS GRACILIOR (O. Hoffm.) Sherff, BOT. GAZ. **76**:84. 1923; *Coreopsis exaristata* var. *gracilior* O. Hoffm., Engler Pflanzenw. Ost-Afr. **C**:414. 1895.

The two sheets of material (*Stuhlmann* 6403 and 7584) cited by OTTO HOFFMANN for his var. *gracilior* differ from his species proper in having the leaves less glandular-pubescent or sometimes even glabrate, their divisions finer and much more acute or even acuminate, the involucre less pubescent and the achenes not being only 3–4 mm. long with all except the innermost ones oblanceolate, but being rather 4.5–6 mm. long and all linear. The important achenial differences seem to have been overlooked entirely by HOFFMANN.[2] A specimen collected later by *Holtz* (no. 406, Dar-es-Salaam, German East Africa, December 6, 1901) in the immediate vicinity of the type locality, Usaramo,[3] agrees fairly well with the type as to foliage and involucre, and has likewise the longer achenes. These important characters of foliage and achenes appear to entitle HOFFMANN'S variety to separate specific rank. The following description is drawn from the STUHLMANN and HOLTZ plants:

BIDENS GRACILIOR (O. Hoffm.) Sherff, descript. amplific.—Herba perennis, gracilis, erecta, 4–7 dm. alta, caule angulato, ramoso. Folia petiolata petiolis tenuibus 0.5–2 cm. longis, petiolo adjecto 3.5–8 cm. longa, circumambitu triangulato-ovata, 1–2-pinnati-partita, segmentis ovato-lanceolatis vel lanceolato-linearibus, membranaceis, atro-punctulatis, dentibus acerrime indurato-apiculatis. Capitula tenuiter pedunculata pedunculis 4–16 cm. longa, radiata, pansa ad anthesin 2.5–4 cm. lata et 6–9 mm. alta. Involucrum glabratum vel moderate pubescens, bracteis exterioribus 6–8, linearibus, acriter cartilagineo-apiculatis, 4.5–6.5 mm. longis, quam interioribus lanceolatis plerumque paulo brevioribus. Flores ligulati circ. 8, lutei, ligula elliptico-oblanceolati, apice obscure denticulati, 1.2–1.8 cm. longi. Achaenia linearia, obcompressa, atra, supra erecto-setosa, exalata, 4.5–6 mm. longa et 0.6–1 mm. lata,

[2] Many mature achenes on the type, *Stuhlmann* 6403 (Herb. Berl.) have 1 or 2 minute aristae (0.2–0.3 mm. long) and several have these aristae retrorsely barbed with 1 or 2 barbs. Had HOFFMANN noticed this character he certainly would have remarked upon it, probably even referring his specimen not to *Coreopsis* but to *Bidens*, since with him the retrorse-barb character was considered diagnostic of the genus *Bidens* (*cf.* SHERFF, BOT. GAZ. **59**:305–308. 1915).

[3] Spelled also Uzaramo (Century Atlas, 1899).

apice calva vel breviter biaristata aristis nudis vel retrorsum 1- vel 2-hamosis et tantum circ. 0.2–0.3 mm. longis.

BIDENS ANDICOLA H.B.K., Nov. Gen. et Sp. 4:237 (186). 1820; *B. andicola* H.B.K. vars. *normalis* and *heterophylla* O. Kuntze, Rev. Gen. Pl. 3[II]:136. 1898; *B. fruticulosa* Mey. and Walp., Nov. Act. Nat. Cur. 19 Supplem. I. 271. 1843.

Descript. amplific.—Herba perennis, semi-procumbens vel etiam erecta, valde hispido-pubescens vel fere glabra, ramosa, 2–8 dm. alta, caulibus parce angulatis. Folia 1–7 cm. longa, valde polymorpha; nunc indivisa, ovata, serrata, sessilia vel alato-petiolata, ad apicem obtusa vel subacuta; nunc tripartita vel 1–3-pinnata foliolis ovatis vel lanceolatis vel linearibus et ad apicem sensim vel abrupte apiculatis. Capitula ramos terminantia, longe pedunculata, radiata; pansa ad anthesin 2–4 vel rarius etiam usque ad 5.5 cm. lata, 0.7–1.4 cm. alta. Involucrum perspicue hispidum, bracteis exterioribus 8–10, lanceolatis vel lineari-oblongis, ciliatis, supra saepe glabratis, apice plerumque obtusis, quam interioribus lanceolatis dense hispidis plerumque multo brevioribus. Flores ligulati saepius 8, lutei, ligula elliptico-oblanceolati, apice plerumque minute 3-denticulati, 1.2–2.5 cm. longi. Achaenia tenuiter linearia, inferne sensim attenuata, obcompresso-quadrangularia, sulcata, supra plus minusve erecto-hispida, fusco-nigra, corpore 0.7–1.4 cm. longa et 0.4–1 mm. lata et paleas demum superantia, apice bi- (vel pauca tri-) aristata, aristis tenuibus, brunneo-stramineis vel rubescentibus, retrorsum hamosis, 1.7–3 mm. longis.

BIDENS ANDICOLA var. DECOMPOSITA O. Kuntze, *l.c.*; *B. macrantha* Griseb., Abhandl. Goett. 19:138. 1874; *B. grandiflora* Balb. var. *breviloba* O. Kuntze, *l.c.*—Folia 2–3-pinnatisecta, usque ad 1 dm. longa, achaeniis superne valde attenuato-elongata.

For many years the identity of the South American *Bidens andicola* has been obscured for herbarium workers by the great multiplicity of foliage forms encountered. WEDDELL, as early as 1856 (Chloris And. 1:70) described it as a polymorphous plant ("Plante polymorphe et très repande dans la chaine, mais presque exclusivement alpestre"). Later, OTTO KUNTZE, who like WEDDELL had collected in South America, commented upon the variability of the leaves ("Eine robuste Art mit einfach oder mehrfach ternatisecten Blättern, mittelgrossen gelben Strahlblüthen, ziemlich grossen Blüthenköpfen, äusseren zottig

behaarten Involucralbracteen etc., aber in Bezug auf Blatttheilung wie manche andere Bidens-Art sehr variabel"; Rev. Gen. Pl. 3[II]:136. 1898). In herbaria the numerous foliage forms are seen to simulate corresponding forms of *B. triplinervia* H.B.K. (*B. humilis* H.B.K., *B. crithmifolia* H.B.K., etc.), and this has led often to confusion between the two species. Recently I was enabled, through the courtesy of OTTO BUCHTIEN (*cf.* SHERFF, BOT. GAZ. **76**:151. 1923), to study a great number of specimens collected by him and displaying a wide range of variation. From these (all in Herb. Field. Mus.) and many others, totalling more than two hundred specimens, the preceding descriptions are drawn. It was found that sometimes, in poorly developed material, distinction from *B. triplinervia* is apparently impossible. In well developed material, however, the distinctions are usually very definite, *B. andicola* being coarser, its thicker heads having commonly about eight instead of commonly about five rays,[4] etc. *B. andicola* has the paleae shorter than the mature achenes and this character separates it from the surprisingly similar aggregation of Mexican forms (*Purpus* 1547, 1548, 2637, 4135, 5089, 5620; *Rose* and *Painter* 6666, 7949; *Pringle* 4915; *E. W. Nelson* 3220, etc.) that in late years have passed erroneously under the name *B. daucifolia* DC. In the latter[5] the paleae are usually very blackish above and commonly surpass the mature achenes.

The type sheet of *B. fruticulosa* Mey. and Walp. is in Berlin. It bears two small specimens collected by MEYEN in April, 1831, about Tacora, Peru. The leaves are undivided, ovate to oblanceolate, and only about 1 cm. long. The heads are 6–8-ligulate. The plants match very closely a certain form found among the Buchtien plants already cited (no. 4305), and thus are seen to be merely an extreme form of *B. andicola*.

Occasionally a form of *B. andicola* is found with the leaves highly compound and the achenes strongly narrowed above, somewhat like those of *Cosmos*. If it were not for various connecting forms this would seem to be specifically distinct. KUNTZE, who himself collected specimens of it, referred at least one of them, a plant from Cochabamba, Bolivia (Herb. N.Y. Bot. Gard.) to *B. andicola*, naming it var. *decomposita*. In a careless moment he named a precisely identical form from between Cochabamba and Rio Juntas, Bolivia (Herb. N.Y. Bot. Gard.) *B. grandiflora* Balb. var. *breviloba*, although *B. grandiflora* is a Mexican species and is not known to occur in South America.

To KUNTZE's variety *decomposita* must be referred *B. macrantha* Griseb., founded on a plant by P. G. LORENTZ, no. 316, alpine pastures near Cienega, Province Tucuman, Argentina. The type is extant in good condition (Herb. Berl.). Although lacking mature achenes, it is seen to match very closely the Bolivian specimens of var. *decomposita*, except in the unimportant respect that it has somewhat larger rays.

[4] Unfortunately, *B. triplinervia* produces at times an 8-rayed form. Discussion of this form must be deferred until a later date.

[5] To be treated in a subsequent paper.

Bidens urophylla, sp. nov. (Pl. II)—Herba glabra, verisimiliter perennis scandensque, forsitan 1–3 m. alta vel longa; ramis aegre angulatis vel teretibus. Folia petiolata petiolis tenuibus 2.5–4.5 cm. longis, petiolo adjecto 8–14 cm. longa, pinnatim 3–5-partita, foliolis anguste lanceolatis, membranaceis, usque ad 1.6 cm. latis, valde et perspicue (prominentibus anguste linearibus 1–3.5 cm. longis) caudato-acuminatis, pauciserrata unico latere 2–6 mucronatis dentibus munito, margine eciliatis. Capitula radiata, pansa ad anthesin ±3 cm. lata et 0.9–1.4 cm. alta, maximam partem verisimiliter corymboso-paniculata. Involucri bracteae exteriores 6–8, anguste lineares, subglabrae, crassiusculae, apice subacutae, 5–8 mm. longae; interiores latiores et paulo longiores. Flores ligulati 5 vel 6, sicci albo-flavidi, ligula oblongo-elliptici, apice denticulati, ±1.5 cm. longi. Achaenia matura non visa; sub matura fusco-nigra, linearia, plana vel subtetragona, corpore 9–12 mm. longa et circ. 1 mm. lata, omnino etiam ad margines glabra vel ad summam sparsissime setulosa, biaristata aristis supra retrorsum infra antrorsum hamosis, tantum circ. 1 mm. longis.

Karl Friedrich Philipp von Martius, in thickets ("sepibus") at the margins of forests near Mariana, Minas Geraes, Brazil, in years 1817–1820 (April; type in Herb. Univ. Munich).

The type had been labeled *Bidens rubifolia* H.B.K., probably by J. G. BAKER. Indeed, from its general habit, the species does appear to be without doubt a close relative of such species as *B. rubifolia* H.B.K., *B. squarrosa* H.B.K., *B. speciosa* Gardn., *B. reptans* (L.) G. Don, *B. Holwayi* Sherff, and *B. Shrevei* Britton, all of them perennial climbers. From these it differs decidedly, however, in its remarkably caudate-tipped leaflets and in its achenes, which are almost entirely glabrous, even on the margins, and have only short aristae.

BIDENS AUSTRALIS Spreng. Syst. **3**:453. 1826; *Coreopsis fruticosa* Forst. Prodr. Fl. Ins. Austr. 91. 1786 (*nomen; non* Vest); *Campylotheca australis* (Spreng.) Less., Linnaea **6**:509. 1831; *Bidens paniculata* Hook. and Arn. Bot. Beech. Voy. 66. 1841; *B. fruticosa* Schz. Bip., Flora **39**:358. 1856 (*non* L., *non* DC.); *Coreopsis fruticosa* Solander *mss.*, in SEEMAN Fl. Vitiensis 143. 1865–1868.

In 1769, BANKS and SOLANDER collected fine material of this species on the Society Islands (Tahiti, *fide* Sol. in Seem. *l.c.*) and on the Friendly Islands. These collectors were attached to Capt. COOK on the first of his three famous voyages (*cf.* Encycl. Brit. edit. 11, **3**:333. 1910). Further specimens were col-

lected at Tahiti on Capt. Cook's third voyage. Both sets of material are still extant in excellent condition (Herb. Brit. Mus.). A sheet from the first voyage (Society Islands) bears the determination *Coreopsis fruticosa* Mscr.[6] One from the third voyage bears the name *Coreopsis fruticosa* Sol. In Solander's unpublished manuscript, at the British Museum of Natural History, is his very complete and precise description of these plants under the name *Coreopsis fruticosa*. This description was not published until 1865–68 (Seemann, *l.c.*).

Meanwhile, Forster, who was botanist on Capt. Cook's third voyage (*cf.* Encycl. Brit. edit. 11, 10:674. 1910), listed a *Coreopsis fruticosa* with the habitat "*intra tropicos*." He gave no description, and so the name, with him, amounts to merely a *nomen nudum*. In fact, it seems entirely plausible that he meant merely to list a plant collected by him on Cook's third voyage and which he had found to match Solander's contemplated species that had been collected on Cook's first voyage. Forster's small and rather scanty private specimen went into the hands of Sprengel, who gave the first published description of it under the new name *Bidens australis*. This historic fragment later became the possession of Schultz Bipontinus, still later of E. Cosson, and now is in Paris (Herb. Mus. Hist. Nat.). It agrees precisely with the material in London, already mentioned as having been collected likewise on Cook's third voyage. Schultz Bipontinus (*l.c.*) gave a very full description of Forster's fragment, evidently unaware of the much more ample duplicate material in London. Nor does he seem to have known of the synonymous *Bidens paniculata* Hook & Arn., based on Capt. Beechey's plant from Tahiti (type in Herb. Kew).

The five fruiting heads remaining on Forster's private fragment have achenes measuring, aristae included, about 3 mm. long (*cf.* Schz. Bip. *l.c.*, "1 Linie lang, oder etwas länger"). Those on the duplicate material studied by Solander vary in length from 3 to 6 mm. (*cf.* Sol. in Seem. *l.c.*, "bilinearia"). Those on the type of *B. paniculata* Hook. & Arn. average slightly smaller, varying from 2.5 to 3.9 mm. long, but this difference seems without much significance.

Asa Gray (Proc. Amer. Acad. 5:128. 1861) erroneously associated this species with the Hawaiian *B. sandvicensis* Less. Drake (del Castillo, Ill. Fl. Ins. Mar. Pacif. 209–210. 1890) erroneously referred it to *Bidens Menziesii* (Gray) Sherff (*Coreopsis Menziesii* Gray), but he had already given a good picture of it under the name *Bidens paniculata* H. & A. (*l.c.* Pl. 40. 1888). From its general habit, also its much smaller and more numerous heads, it is seen to be affiliated more closely with such species as *B. polycephala* Schz. Bip. and *B. Ahnnei* Sherff, both of the southern Pacific, than with species such as *B. sandvicensis* Less. of the Hawaiian region. Nor does *B. australis* resemble at all closely *B. lantanoides* Gray, which Seemann (*l.c.*) thought was "probably identi-

[6] The Banks and Solander specimen at Paris is from the Friendly Islands (1769). It matches the Society Island plants, but the label bears none of Solander's own notations.

cal." From the specimens studied by me, SPRENGEL's meager description may now be amplified as follows:

BIDENS AUSTRALIS Spreng., descript. amplific.—Suffruticosa, glabra, usque ad 1.8 m. alta; caule obtuse tetragono vel subtereti, erecto, ramoso vel saepe ramosissimo. Folia tenuiter petiolata petiolis 1–3 cm. longis, petiolo adjecto 6–13 cm. longa, indivisa, lanceolata oblongave et apice plerumque acuminata, serrata dentibus parvis et plerumque 20–40 in unico latere, non ciliata. Capitula parva, paniculato-corymbosa, supra folia exserta, minute radiata, ad anthesin 6–7.5 mm. lata et 3–4 mm. alta, tenuissime pedunculata pedunculis 1–3 cm. longis. Involucrum vix hispidulum vel profecto saepe glabrum; bracteis exterioribus 5–7, minimis, linearibus, supra saepe dilatatis, apice plerumque subobtusis, raro subciliatis, circ. 1 mm. longis; interioribus lanceolatis, circ. 2 mm. longis. Flores ligulati circ. 5, minimi, ligula late ovati vel oblongi, apice plerumque denticulati, flavi, 2–3 mm. longi. Achaenia minuta, linearia, infra parce angustata, obcompresso-tetragona vel subplana, atra, sparsim suberecto-setosa, paleas saepe superantia, corpore 2.5–6.6 mm., brevissime biaristata aristis divergentibus, retrorsum hamosis, 0.2–0.5 mm. longis.

Specimens examined.—*Banks* and *Solander*, Tahiti, 1769 (Herb. Brit. Mus.); *iidem*, Friendly Islands (Herb. Paris); Capt. *Beechey*, Tahiti (Herb. Kew); *Bertero* and *Moerenhout*, Tahiti, 1831 (Herb. E. Drake in Herb. Paris); *Bidwill*, Morea (Eimeo; Herb. Kew); *J. G. Forster*, Tahiti (Herb. Brit. Mus.; Herb. Paris); *Lepine* 98, Tahiti (Herb. Kew); *Moerenhout*, Tahiti, 1834 (Herb. Paris); *J. Nadeaud* 336, on precipices, Tahiti, June 1, 1857 (Herb. E. Drake in Herb. Paris); *Webb*, Tahiti (Herb. Kew).[7]

Bidens Mathewsii, sp. nov.—Glabra, supra herbacea, infra verisimiliter suffruticosa, forsitan 6–10 dm. alta, ramis angulatis. Folia tenuiter petiolata petiolis 1–2 cm. longis, petiolo adjecto 7–10 cm. longa, indivisa, lanceolata vel oblongo-lanceolata, membranacea, serrata dentibus parce mucronatis, eciliata, apice acuta. Capitula pauca (±8 in unico ramo), corymbosa, supra folia exserta, radiata, pansa ad anthesin ±0.8 cm. alta et ±1.3 cm. lata. Involucri brac-

[7] CHAMISSO's specimens from Oahu Island, cited by LESSING (Linnaea 6:509. 1831) for this species, are merely fragments with branchlets and leaves, but more or less deficient as to heads (Herb. Univ. Halle, Herb. Kew). They match *B. micrantha* Gaud., a Hawaiian species with compound leaves and very different from *B. australis*.

teae exteriores 8–10, oblongo-lineares, glabratae, apice obtusae, 3–6 mm. longae; interiores lanceolatae, paulo longiores, versus basim saepe minute pulverulentae. Flores ligulati ±5, lutei, ligula elliptico-oblongi, apice plus minusve denticulati, ±7 mm. longi. Achaenia paleis elongatis parce aequantia, plerumque anguste rarius late linearia, plana vel obcompresso-triquetra, exalata, atra, dense erecto-hispida pilis stramineis, corpore 5–8 mm. longa et 0.5–1 mm. lata. apice biaristata aristis retrorsum hamosis 0.5–1 mm. longis.

A. Mathews 110, Pitcairn Island, March, 1830 (type in Herb. Kew).

A plant with the foliage habit of *Bidens australis* Spreng., but having fewer and larger heads, more numerous and more uniformly linear (not apically dilated) exterior involucral bracts, and larger, much more hispid achenes.

BIDENS PILOSA, var. ALAUSENSIS (H.B.K.), comb. nov.; *B. alausensis* H.B.K. Nov. Gen. et Sp. **4**:184 (235). 1820; *B. valparadisiaca* Colla, Mem. Accad. Torin. **38**:12. *pl. 24.* 1835; *B. chilensis* DC. Prodr. **5**:603. 1836; *B. valparadisea* Colla *ex* Philippi Cat. Pl. Chil. 155. 1881.

In a former article I have discussed the identity of *B. valparadisiaca* Colla and *B. chilensis* DC. with *B. alausensis* H.B.K., and presented photographs of KUNTH'S type of *B. alausensis* H.B.K. (BOT. GAZ. **59**:310–311. *fig. 1.* 1915). In 1924 I made a careful reexamination of KUNTH'S type and four sheets of cotype material (Herb. Paris, Herb. Berl.) and came again to the same conclusion as before. A study of various other specimens, however, shows that *B. alausensis* H.B.K. cannot properly be regarded as specifically distinct from *B. pilosa* L. Thus, for example, *J. Francis Macbride* 2899 and 2901, at altitude of about 8000 ft., Matucana, Peru, March 14–18, 1923 (Herb. Field Mus.)[8] and *Poeppig* 207, *prope* Valparaiso, Chile (type and cotypes of *B. chilensis* var. *apiifolia* DC.; Herb. DC., Herb. Mus. Vienna, Herb. Univ. Kiel, etc.) have tripartite leaves and are forms of *B. pilosa* var. *radiata* Schz. Bip.[9] But *Macbride* 2902 (Herb. Field Mus.), collected at the same place and same time as *Macbride* 2899 and 2901, has the foliage mostly bipinnatisect, and is very close to or identical with various specimens of *B. alausensis* H.B.K. from Chile and Ecuador. *Macbride* 2900, altitude about 8000 ft., Matucana, Peru, March 14–18, 1923 (Herb. Field Mus.), and 3473, at altitude of about 8500 ft., Cani, Peru, April

[8] These and the other MACBRIDE specimens cited were very kindly obtained for me by Mr. MACBRIDE, who had the matter particularly in mind on his recent South American Expedition. Of each number cited I have seen all the duplicates before their distribution to other herbaria.

[9] Having rays mostly 5–8 mm. long and slightly more yellowish than usual in the var. *radiata*. They suggest in the ray characters the allied forms that pass under the name *B. pilosa* var. *minor* (Bl.) Sherff.

16–26, 1923, also are identical in habit and technical characters with *B. alausensis*, except that they are taller and more robust and their foliage is more finely cut, becoming even tripinnatisect. These are identical with *A. D'Orbigny* 1234, Bolivia (Herb. Paris), labeled *Bidens scandicina* var. *glabrescens* by WEDDELL. They match also the Berlin and Paris cotypes (now before me) of *B. scandicina* H.B.K., except that the latter have more pubescent leaves with somewhat finer divisions. It is significant that the types of *B. alausensis* H.B.K. and *B. scandicina* H.B.K., here seen to be so closely connected by intermediate specimens, were collected by HUMBOLDT and BONPLAND in the same vicinity: *B. alausensis* between Alausi and Tambo de Guamote, Ecuador, and *B. scandicina* between Llactacunga and Hambato, Ecuador.

It might seem at first that we have here a situation comparable with that in *B. pilosa* var. *bimucronata* (Turcz.) O.E.S., where the form with finely divided foliage is reducible to subordinate rank as f. *odorata* (Cav.) Sherff. In such a case we should have the names *alausensis* and *scandicina* taking respectively *formal* and *subformal* rank under the name *B. pilosa* var. *radiata*, giving names which would be very cumbersome. It seems more probable, however, that in the present case the *alausensis* and *scandicina* forms do not intergrade nearly so much with *B. pilosa* var. *radiata* as does the *odorata* form with *B. pilosa* var. *bimucronata*. Hence there appears good reason for assigning *B. alausensis* varietal status directly under *B. pilosa*, and reducing *B. scandicina* to a *forma* under the variety:

B. PILOSA var. ALAUSENSIS f. SCANDICINA (H.B.K.), comb. nov.

Specimens examined, (*a*) var. *alausensis*.—*J. Ball*, alt. 12,000–13,000 ft., *ex saxosis andium peruviae juxta pagum* Chicla, April 21–23, 1882 (Herb. Kew); *D. Bertero* 845 *pro parte*, Quillota, Chile, October–November, 1829 (type of *B. chilensis* DC. in Herb. DC.; cotype, Herb. Par.); *idem* 845 *pro parte, in pascuis sylvaticis et ad ripas collium*, Valparaiso, Chile, 1830 (Herb. Mus. Vienna; Herb. N.Y. Bot. Gard.; Herb. Brit. Mus.; Herb. Mun.); *Bridges*, Valparaiso, Chile, 1830 (Herb. Kew); *idem* 66, Valparaiso, Chile, 1832 (Herb. Brit. Mus.; Herb. Kew; Herb. Mus. Vienna); *Otto Buchtien*, Valparaiso, Chile, August 20, 1895 (Herb. Field Mus.); *Agnes Calvert*, Valdivia and Valparaiso, Chile (Herb. Brit. Mus.); *Cruckshank*, Chile (Herb. Kew); *H. Cuming* 646, *prope* Valparaiso, Chile 1831 (Herb. Brit. Mus.; Herb. Mus. Vienna; Herb. Webb); *Frömbling*, Chile, 1886 (Herb. Mun., 2 sheets); *Gaudichaud* 164, Valparaiso, Chile, 1834 (Herb. DC.; Herb. Webb.); *Cl. Gay* 201, Chile, 1833 (Herb. DC.; Herb. Gray, 2 sheets); *idem* 341, *in collibus*, Prov. de Coquimbo, Chile, August, 1829 (Herb. Par.); *idem* 355, *in collibus*, Chile (Herb. Par.); *W. H. Harvey*, Valparaiso, Chile, April–July, 1856 (Herb. Gray); *Humboldt* and *Bonpland*, alt. 7800 ft., between Alausi and Tambo de Guamote, Ecuador (type and cotype in Herb. Par.); *J. Francis Macbride* 2902, on slide rock, alt. about 8000 ft., Matucana, Peru, March 14–18, 1923 (Herb. Field Mus.); *Macrae, prope* Valparaiso, Chile, 1825 (Herb. Kew); *Mathews* 465, in interior Peru, 1862 (Herb. N.Y. Bot. Gard.); *idem* 468, Pur-

ruchuco, Peru (Herb. Kew); *Herb. Miers* 67, Concon, Chile (Herb. Brit. Mus.); *Mosely* (Challenger Exped.), Juan Fernandez, Chile, November, 1875 (Herb. Kew); *F. W. Neger*, Concepcion, Chile, July 20, 1895 (Herb. Mun.); *F. Philippi*, Valparaiso, Chile, 1894 (Herb. Brit. Mus.); Mr. and Mrs. *J. N. Rose* 19114, near Valparaiso, Chile, September 14, 1914 (Herb. U.S. Nat.); *R. E. Snodgrass* and *E. Heller* 887, at alt. 4000 ft., Tagus Cove, Albermarle Island, Galapagos Islands, June 15, 1899 (Herb. Gray); *Alban Stewart* 716, abundant in thickets at alt. 4000 ft., Tagus Cove, Albermarle Island, Galapagos Islands, March 24, 1906 (Herb. Brit. Mus., Herb. Mo. Bot. Gard.); Dr. *Wawra* (H. M. Frigate "Donau"), Valparaiso, Chile, 1868–1871 (Herb. Mus. Vienna).

Specimens examined, (*b*) f. *scandicina*.—*Otto Buchtien*, alt. 3500 m., La Paz, Bolivia, May, 1911 (Herb. Mun.); *idem* 378, at alt. 3460 m., La Paz, Bolivia, March 8, 1919 (Herb. Field Mus., 2 sheets); *idem* 811, at alt. 3460 m., La Paz, Bolivia, March 8, 1919 (Herb. Field Mus., 2 sheets); *idem* 811, at alt. 3460 m., La Paz, Bolivia, March 8, 1919 (Herb. Field Mus., 2 sheets).[10] *Const. de Jelski* (*distrib. Dr. Ign. de Szyszylowicz*) 657 and 735, Cutervo, Peru, April, 1879 (Herb. Berl.); *A. D'Orbigny* 1234, Bolivia (Herb. Par., *sub. nom. B. scandicina* var. *glabrescens* Weddell); *Humboldt* and *Bonpland*, between Llatacunga and Hambato, Ecuador (type and 2 cotype sheets in Herb. Par.; 2 cotype sheets in Herb. Berl.); *J. Francis Macbride* 2900 *pro parte*, very rocky valley floor, alt. 8000 ft., Matucana, Peru, March 14–18, 1923 (Herb. Field Mus., where two of the duplicate sheets bear plants with less divided foliage and are referable to the var. *alausensis* proper); *idem* 3473, alt. about 8500 ft., Cani (pueblo 7 miles northeast of Mito), Peru, April 16–26, 1923 (Herb. Field Mus.); *A. Sodiro, in campis interandinis prope* Pomasqui, Ecuador, February, 1896 (Herb. Berl., 2 sheets).

BIDENS FERULAEFOLIA (Jacq.) DC. Prodr. **5**:603. 1836; *Coreopsis ferulaefolia* Jacq. Hort. Schoenbr. **3**:65. *pl. 375*. 1798; *Bidens procera* D. Don, Bot. Reg. **8**:684. *pl. 684*. 1822; *Coreopsis angustifolia* Pavon *ex* D. DON *l.c.*; *Kerneria ferulaefolia* (Jacq.) Cass. Dict. **51**:473. 1827.

The type of *B. procera* Don had been raised from seed sent by DON JOSE PAVON to Mr. LAMBERT. PAVON had received the material from Mexico, but the exact locality in Mexico is not stated by DON. I have not knowingly seen the Lambert Herbarium specimens which DON cited, but there lies before me an

[10] In the BUCHTIEN specimens the similarity to certain Umbelliferae, implied in the name *scandicina*, is most striking. In fact, before seeing the SODIRO (*cf.* HIERONYMUS, Engler Bot. Jahrb. **29**:48. 1901) and DE JELSKI specimens, I myself had not thought to connect the BUCHTIEN specimens with f. *scandicina*, and had tentatively considered them as representing a new species. Curiously enough, I too had been impressed with the resemblance to certain Umbelliferae, especially *Musineon*, and, to a lesser extent, *Chaerophyllum*, and had tentatively employed a trivial name based upon this resemblance. In one specimen by BUCHTIEN (no. 811) the foliage and general habit suggest also those of *Anthemis Cotula* L.

original specimen of PAVON's own herbarium (*ex* Herb. Boiss.). This agrees with DON's description and plate fairly well, the chief differences being attributable to the fact that DON based his description mainly on the taller and more robust cultivated plants. Thus, early in his description, DON described his plant as "*orgyalis v. ultra*," and later on he described it as "6 or 8 ft. high." I have seen no spontaneous specimens that measured nearly so tall as in DON's cultivated plants. These latter, however, are seen from DON's description and plate to match the original plate and the various cultivated specimens (extant in European herbaria) of *B. ferulaefolia* (Jacq.) DC.

Most of the spontaneous specimens have a low stature (5–8 dm. high) and slender branches; very rarely have they been found to resemble the cultivated plants (illustrated especially well in JACQUIN's plate), and then they appear to have grown in an aqueous habitat.

Specimens examined.—*Frère G. Arsène* 3080, vicinity of Morelia, Michoacan, Mexico, in 1910 (Herb. Berl.); *E. Bourgeau* 502 *pro parte* Guadalupe (Hidalgo), near City of Mexico, Mexico, August 23, 1865–66 (Herb. Berl.; Herb. Boiss.; Herb. U.S. Nat.); *C. V. Hartman* 47, in water ditch, Fronteras, Sonora, Mexico, September 25, 1890 (Herb. Gray); *idem* 834, San Pedro, Sonora, Mexico, September 14, 1890 (Herb. Gray); *idem* 961, between San Pedro and Fronteras, Sonora, Mexico, September 20–24, 1890 (Herb. Gray); *idem* 991, Fronteras, Sonora, Mexico, September 25–29, 1890 (Herb. Gray); *Herb. Fauche* 50 (Herb. Boiss.); *J. Gregg* 397, Mexico, 1848–49 (Herb. Gray); *Jacquin* fil., cult. in 1809 (Herb. DC. Prodr.); *J. G. Lemmon*, southern Arizona, 1881 (Herb. Gray); Mr. and Mrs. *J. G. Lemmon*, Rucker Valley, Chiricahua Mts., Arizona, September, 1881 (Herb. Brit. Mus.; Herb. Univ. Calif.); *iidem* 2768, spring at "Hermitage," Rucker Valley, Chiricahua Mts., Arizona, September, 1881 (Herb. Univ. Calif.); *Hort. Bot. Monac.*, in 1845 (Herb. Mun., 4 sheets); *Edward Palmer* 316 and 393, southwestern Chihuahua, Mexico, August to November, 1885 (Herb. Gray); *idem* 425 and 426, Guadalajara, Jalisco, Mexico, July to October, 1886 (425, Herb. Univ. Vienna; 426, Herb. Boiss.; Herb. U.S. Nat.); *idem* 668, 672, and 677, vicinity of City of Durango, Durango, Mexico, April to November, 1896 (668, Herb. Univ. Calif.; 672, Herb. U.S. Nat.; 677, Herb. Berl. and Herb. Gray); *idem* 933, wet bottoms along water courses, vicinity of City of Durango, Durango, Mexico, July to November, 1896 (Herb. Berl.; Herb. Boiss.; Herb. Gray; Herb. Univ. Calif.); *Hort. Paris.*, November 1, 1814 (Herb. Kew); Herb. PAVON, *sine patria et sub nom. Coreopsis tripinnatifida* (Herb. Boiss.); *idem*, Mexico (Herb. Boiss.); Hort. *Pelon*, November, 1819 (Herb. Kew); *C. G. Pringle* 136, Mexico (Herb. Gray); *J. N. Rose* 2530, Huejuquilla, Jalisco, Mexico, August 24, 1897 (Herb. Gray); *J. T. Rothrock* 671, Sannoita Valley, southern Arizona, September, 1874 (Herb. Gray); *Schaffner*, near St. Angelum, Mexico, September, 1855 (Herb. N.Y. Bot. Gard.); *idem* 213, Valley of Mexico, Mexico (Herb. Berl.; Herb. Gray); *W. Schumann* 108, river bank, Faral, Mexico, September 10, 1885 (Herb. Berl. 2 sheets; Herb. Univ. Vienna); *George Thurber* 1102, Sonora, Mexico, September 11, 1851 (Herb. Field Mus.; Herb. Gray);

J. W. Toumey 58, Chiricahua Mts., Arizona, July 26, 1899 (Herb. Univ. Calif.); *C. H. T. Townsend* and *C. M. Barber* 315, altitude of 7200 feet, Chihuahua, Mexico, September 6, 1899 (Herb. Boiss.); *C. Wright* 1232, Sonora, Mexico, in 1851 (Herb. Gray); *Herb. Zucarini*, cult. in 1817 (Herb. Mun.).

BIDENS FERULAEFOLIA var. FOENICULAEFOLIA (DC.), comb. nov.; *B. foeniculaefolia* DC. Prodr. **5**:603. 1836; *Coreopsis foeniculacea* Moc. and Sesse *ex* DC. *l.c.*

The type material of *B. foeniculaefolia* DC. was collected in 1829, partly by MENDEZ and partly by ALAMAN, some plants to the west and some to the south of Guanajuato, Leon, Mexico. Besides the four type sheets in the De Candolle Prodromus Herbarium, duplicates are in Paris and Florence. ASA GRAY suspected *B. foeniculaefolia* DC. of belonging to *B. procera* (Synopt. Fl. **1**[II]:298. 1884; *cf.* Proc. Amer. Acad. **19**:16. 1884). The resemblance is very close, but *B. foeniculaefolia* tends to have a more wiry aspect, with narrower leaf divisions, and more pubescence. The achenes are less numerous and less compactly arranged in the heads than those of typical *B. procera*, or *B. ferulaefolia* as we must call it. Furthermore, their bodies average about 8 mm. long and 0.6 mm. wide, while the bodies of *B. ferulaefolia* are usually shorter and wider than this. The aristae are usually 2, but at times 3 or 4,[11] while in *B. ferulaefolia* they seem constantly 2. At the most, however, *B. foeniculaefolia* does not exhibit enough differences from *B. ferulaefolia* to warrant more than varietal distinction. Besides the original specimens, I have examined the following: *J. Gregg* 397, Mexico, September 1, 1848–49 (Herb. Mo. Bot. Gard.); *Nicholas*, Puebla, Mexico, June 9, 1910 (Herb. Par.); *Edw. Palmer* 681, vicinity of City of Durango, Durango, Mexico, September, 1896 (Herb. Berl.); *George Thurber* 1102, Sonora, Mexico, September, 1851 (Herb. Field Mus.).

BIDENS FERULAEFOLIA var. LUDENS (A. Gray), comb. nov.; *B. ludens* A. Gray, Proc. Amer. Acad. **21**:390. 1886.

ASA GRAY, shortly before his death, applied the name *B. ludens* to a plant collected by PRINGLE, no. 293, hills and plains, northwest of the City of Chihuahua, Chihuahua, Mexico, October, 1885 (Herb. Gray). GRAY's type specimens do not differ much in general appearance from *B. procera*. The fruiting heads, however, are noticeable because most of the achenes lack or have dropped their aristae.[12] In certain of the foregoing collections cited for *B. ferulaefolia* proper, however, particularly some of PALMER's plants, there are heads in which most of the achenes have likewise lost their aristae. Indeed, DON himself had noted this as one of the characters of his *B. procera*.[13] Another character noted in

[11] DE CANDOLLE is seen, from his description ("biaristatis"), to have overlooked the additional aristae on his own material.

[12] ". . . . aristis subulatis . . . . (persistentibus vel deciduis)"—GRAY, *l.c.*

[13] ". . . . aristis . . . . deciduis . . . . having flat cuneiform seed with deciduous (not permanent) awns." DON, *l.c.*

GRAY'S type material is the usually greater proportionate length of the mature paleae. In most of the heads they are larger than the achenes, but on the same plant some heads may be found with exceptionally long achenes, these surpassing the paleae. Evidently GRAY'S *B. ludens* is best regarded as merely a variety of *B. ferulaefolia*. Besides the type material, I have examined the following specimens: *E. W. Nelson* 1438, altitude of 5500–7500 feet, Valley of Oaxaca, Oaxaca, Mexico, September 20, 1894 (Herb. Gray; Herb. U.S. Nat.); *C. G. Pringle* 757 *pro parte*, mountains near City of Chihuahua, Chihuahua, Mexico, October 3, 1886 (Herb. Berl.; Herb. Brit. Mus.; Herb. Univ. Vienna).

BIDENS ABADIAE DC. **pilosoides,** var. nov.—A specie foliis pinnatim 3–5-partitis foliolis ovatis vel terminali lanceolato omnibus serratis vel incisis apice obtusis vel acutis capitulis plerumque eradiatis diversa; habitu *B. pilosae* adpropinquans.

H. Cuming 1041, Lima, Peru, in 1831 (type and cotype in Herb. Kew); *W. Nation*, cultivated places, Lima, Peru, in 1862 (Herb. Kew); ex Herb. Pavon, Peru (Herb. Webb).

Bidens Abadiae DC. was founded upon a specimen collected at Lima, Peru, in 1833 (Herb. DC.). The leaves of the type are bipinnatisect, and the general aspect of the foliage is comparable with that for *B. pilosa* var. *bimucronata* f. *odorata* (Cav.) Sherff. In the Boissier Herbarium is a plant from the Pavon Herbarium and collected at Lima or vicinity, which matches the type very closely in its bipinnatisect foliage. The technical characters of both the old and young heads on these plants are very similar to those often met with in *B. pilosa* L. The general habit is so distinct, however, that to equate *B. Abadiae* and *B. pilosa* would seem unjustifiable.

In the Webb Herbarium at Florence is still another specimen from the Pavon Herbarium, collected in Peru. This has the *leaves merely tripartite*, with the terminal lobe subtripartite. The specimens by CUMING and by NATION, all from Lima, likewise differ from the DE CANDOLLE type in having *leaves only once divided*. One of the CUMING specimens has leaves approaching those of the related *B. pilosa* var. *alausensis* (H.B.K.) Sherff. As the difference between the simply pinnate and the bipinnatisect types of foliage appears here to be emphatic, as in the varieties of *B. pilosa*, I have given the name *pilosoides* to the variety having 3–5-partite leaves.

BIDENS PILOSA var. BIMUCRONATA (Turcz.) O. E. Schulz, Urban Symb. Antill. **7**:138. 1911; *B. bimucronata* Turcz., Bull. Soc. Nat. Mosc. **24**:184. 1851; *B. caracasana* DC. Prodr. **5**:600. 1836.

The name *Bidens caracasana* DC. has been carelessly treated by botanists, having been referred to a number of widely different species. The De Candolle Prodromus Herbarium (Herb. Deless.) contains two sheets of type material,

Vargas 210, Caracas, Venezuela, in 1830. All of this material is the form understood by me (*ex descript. et patr.*) to represent *B. bimucronata* Turcz., recently reduced by O. E. SCHULZ (*l.c.*) to a variety of *B. pilosa* L.

BIDENS PILOSA var. BIMUCRONATA forma ODORATA (Cav.), comb. nov.; *B. odorata* Cav. Icon. **1**:9. *pl. 13.* 1791; *Coreopsis ferulaefolia* var. *odoratissima* Pers. Synops. Pl. **2**:477. 1807; *C. multifida* DC. Prodr. **5**:573. 1836; *C. multifida* var. *mutica* DC., *l.c.*; *B. daucifolia* DC., *l.c.* 601; *Bidens ferulaefolia* var. *odoratissima* (Pers.) DC., *l.c.* 603. 1836; *B. caucalidea* DC., *l.c.* 604; *B. Deamii* Sherff, BOT. GAZ. **56**:490. 1913; *B. ramosissima* Sherff, *l.c.* 491.

For a discussion of *Bidens odorata* Cav. and of *Coreopsis ferulaefolia* var. *odoratissima* Pers., reference is made to an earlier paper (BOT. GAZ. **59**:304. 1915).

Coreopsis multifida DC. and its var. *mutica* DC. are represented by the type specimens in the Herbarium of De Candolle's Prodromus (Herb. Deless.). The species was collected (*ex* DC., *l.c.*) by PAVON, possibly in Peru; the variety was from seed previously sent by DOMBEY from Peru to the Botanical Garden at Paris. Both are found on careful comparisons to be merely *Bidens odorata* Cav.

Bidens caucalidea DC. was described from *Berlandier's* 1138. The sheet of this number in the Museum of Vienna has one specimen with bipinnate leaves, approaching *B. odorata* Cav., and another with some of the principal leaves only tripartite, approaching *B. pilosa* var. *bimucronata* (Turcz.) O. E. Schulz. At Washington (U.S. Nat. Herb.) are two sheets of the fine material collected by ARSÈNE. It is remarkably close to the type material of *B. caucalidea* and might well serve as a supplementary type for the concept represented by that name. Four of the five specimens there have the leaves mainly bipinnate as in *B. odorata* Cav., but the remaining specimen has the leaves tripartite as in *B. pilosa* var. *bimucronata*.[14] Obviously the amount of foliar division is of little value here in determining specific limits. Likewise, a study of various other specimens (referred to *B. odorata* Cav. or to *B. caucalidea* DC.) with reference to achenial shape, size, and armature, to width of flowering heads and to general branching habit, reveals an astonishing amount of variation. A form with the upper part of the main stem broken away and the lower part profusely branched is the plant formerly described as *Bidens Deamii* Sherff. *B. ramosissima* Sherff is probably best interpreted as merely a mutant form with an excessive degree of branching, and the involucres finally becoming reflexed to a notably uniform extent. A specimen collected by SEEMANN (Herb. Kew) is positively the *B. odorata* of CAVANILLES, and yet in its highly branched character displays an approach to the type of *B. ramosissima* (U.S. Nat. Herb.).

[14] *Cf.* O. E. SCHULZ, Urban Symb. Antill. **7**:138. 1911; "Bidens caucalideus DC.! . . . . varietati *bimucronato* valde affinis folia pinnatisecta habet."

Certain specimens of *Berlandier's* 1138 were rather under-developed in stature, somewhat pubescent-hirtellous, and had the leaf segments more acute. These DE CANDOLLE assumed to be another species, confused with the *B. caucalidea* material by BERLANDIER in the gathering. He named them *B. daucifolia*. For *B. daucifolia*, as for his *B. caucalidea*, he described the rays as yellow. Since DE CANDOLLE's day, many yellow-rayed Mexican specimens related to *B. andicola* H.B.K. have been determined by students (myself among them) as *B. daucifolia* DC.;[15] but my recent study of the long neglected type material of *B. daucifolia* at Geneva (Herb. DC.) and Paris (Herb. Mus. Hist. Nat.) showed that *B. daucifolia* is not a yellow-rayed form. The Geneva sheet has a single small specimen, with one flowering and one fruiting head. The ligules are a faded rosaceous color, not yellow as DE CANDOLLE had stated. The achenes are those of *B. odorata* Cav. The Paris sheet has three small but good specimens. Three radiate heads are present, of a faded rosaceous color. One specimen has a head of biaristate achenes and another has two ample fruiting heads of exaristate achenes. These specimens all are mere variations of *B. caucalidea* DC., and there is no reason to suppose that BERLANDIER confused two sorts with each other. Clearly then, *B. daucifolia* DC. and *B. caucalidea* DC. are synonymous, and together must be equated in turn with the earlier *B. odorata* Cav.

A study, in herbaria, of the numerous specimens referable to *B. odorata* Cav., shows no less than eight or ten *facies* or aspects to be found. These might seem to represent a corresponding number of varieties and racial forms. To encumber taxonomy with a great number of additional names, however, when the variations are so capricious and fickle as often to result in two or three unlike *facies* upon a single herbarium sheet, would appear entirely unwarranted. These varying forms, therefore, all of them intimately related to *B. pilosa* var. *bimucronata* but tending to display more or less bipinnate leaves on most of the individual plants, are grouped together by me as the forma *odorata* of that variety.[16] Complicated and undesirable as the name resulting from this interpretation will be, nevertheless it is the only one that appears to accord with the facts in nature.

BIDENS AUREA (Ait.[17]) Sherff, BOT. GAZ. **59**:313. 1915 (*ex synon.* Ait. *nec alior*); *Coreopsis aurea* Ait., Hort. Kew 3:252. 1789 (*non auctores*); *Bidens heterophylla* Ortega Hort. Matr. 99. *pl.* 12. 1798;

[15] Already mentioned under *B. andicola*.

[16] O. KUNTZE (Rev. Gen 1:322. 1891) put forth the even more complicated and unwelcome method of proposing varieties, subvarieties, and forms (*formae*). His name *subbiternata* is seen, on carefully reading the related names, to have been used for a subvariety or group (under *B. pilosa*) ranking lower than a variety but higher than a *forma* (thus *cf. B. pilosa* α *leucantha* 2. *ternata* f. *pilosior, l.c.*). Even were the *formal* rank of the name *subbiternata* accepted, however, it could not conflict with the validity of the claim of *odorata* to *formal* rank, as *subbiternata* pertained to a form of *B. pilosa* var. *radiata* Schz. Bip., not var. *mucronata* (Turcz.) O. E. Schz.

[17] Less commonly, but probably with greater justice, cited "Dryander in Aiton."

B. luxurians Willd. Enum. Hort. Berol. 847. 1809 (*nec alior*); *B. arguta* H.B.K. Nov. Gen. et Sp. **4**:181 (231). 1820; *B. decolorata* H.B.K. *l.c.* 182 (233); *B. arguta* var. *luxurians* DC. Prodr. **5**:596. 1836; *B. longifolia* DC. *l.c.* 597; *B. Warszewicziana* Regel *cum vars.* α, β, γ. Flora **32**:183–184. 1849; *B. heterophylla* var. *Wrightii* Gray, Proc. Amer. Acad. **19**:15. 1883; Synopt. Fl. N. Amer. **1**[II]:298. 1884; *B. heterophylla* var. *typica* Fiori *in* Fiori e Paoletti Fl. Anal. Ital. **3**:303. 1904.

The name *Coreopsis aurea* Ait. has been associated by botanists for more than a century with a plant native to the southeastern United States. The description given by AITON is rather short: "aurea 2 *Coreopsis* foliis serratis: radicalibus tripartitis; caulinis trifidis integrisve lanceolato-linearibus. Hemp-leav'd *Coreopsis*. Nat. of North America. Introd. 1785 by CHARLES EARL of Tankerville. Fl. August & September. H.♃." The specimen collected from the type plants in Kew Garden in 1785, however, is still extant in good condition in the British Museum of Natural History.[18] This specimen bears a superficial resemblance to the plant of the southeastern United States, *Coreopsis mitis* Michx., and from the confusion found in literature, appears to have deceived every botanist who had examined it. I myself misinterpreted it in 1914 (BOT. GAZ. **59**:314. 1915). In 1924, however, having in the meantime determined many hundreds of herbarium specimens of *Bidens heterophylla* Ort., I found immediately on reexamination that AITON's type was merely a cultivated form of that species. This surprising discovery led to a careful search through the remains of the single flowering, worm-eaten head. Two aristae were extracted and these both were retrorsely barbed. Such aristae are entirely unknown in the species from the southeastern United States, but are typical for *B. heterophylla* Ort.[19] Obviously the name *aurea*, published by AITON nine years prior to ORTEGA'S *heterophylla*, and transferred to *Bidens* by me more than a decade ago, must be considered the valid trivial name for this well known species.

BIDENS MITIS (Michx.), comb. nov.; *Coreopsis mitis* Michx. Fl. Amer. Bor. **2**:140. 1803; *C. arguta* Pursh Fl. Amer. Sept. **2**:567.

[18] There is nothing mysterious about the AITON material being in this institution rather than at Kew. The AITON plant had been carried, without doubt, to BANKS or SOLANDER, then got into the Banksian Herbarium, and thus finally found its way, with other Banksian specimens, into the British Museum of Natural History (*cf.* JAMES BRITTEN, Jour. Bot. **50** [supplem. 3]:15. 1912).

[19] Another specimen was found in the same herbarium and coming from the old Chelsea Garden. It had the number 3417 and a copy of the original description of *Coreopsis aurea* was upon the label. It had the same peculiar aspect as the AITON type, so much so that it might well have been gathered from the same plant. All of its achenial aristae were retrorsely barbed.

1814 (*non* H.B.K.); *C. ambigua* Nutt., Jour. Acad. Philad. **7**:75. 1834; *Diodonta mitis* Nutt., Trans. Amer. Phil. Soc. ser. II. **7**:360. 1841; *D. leptophylla* Nutt., *l.c.; Coreopsis aurea* var. *subintegra* Torr. and Gray Fl. N. Amer. **2**:339. 1843; *C. aurea* var. *leptophylla* (Nutt.) Torr. and Gray, *l.c.*, *C. aurea* var. *incisa* Torr. and Gray, *l.c.; Bidens coronata* var. *leptophylla* (Nutt.) Mohr, Contrib. U.S. Nat. Herb. **6**:808. 1901; *B. aurea* var. *leptophylla* (Nutt.) Sherff, BOT. GAZ. **59**:316. 1915.[20]

As already stated, the name *Bidens aurea* (Ait.) Sherff, heretofore considered as pertaining to a species from the southeastern United States, is found to belong to the Mexican species described by ORTEGA as *B. heterophylla*. MICHAUX's name *Coreopsis mitis* is found to be, in reality, the first name published for the former species, which is the species to be considered here. TORREY and GRAY (*l.c.*) divided this species into the three varieties, *subintegra*, *leptophylla*, and *incisa*, on the basis of the amount of leaf division. But in this species the variation in leaf division is so fickle that it is not worth while to attempt the maintenance of varieties. MICHAUX described the leaves but scantily ("foliis petiolatis; infimis duplicato-pinnatifidis; supremis lineari-tripartitis"). I have before me, however, a specimen of his original material (Herb. Berl., *ex* Kunth, to whom it had been given by A. RICHARD in 1827). Its leaf segments are slender and fit the var. *leptophylla* better than the var. *incisa*, to which latter TORREY and GRAY referred it.

Coreopsis ambigua Nutt. is represented by the type, still extant (Herb. Brit. Mus.). It is of the form described by TORREY and GRAY as var. *subintegra*.

BIDENS PILOSA var. RADIATA Schz. Bip. in Barker-Webb and Berth. Hist. Canar. III. 2^{II}:242. 1836–50; *Coreopsis alba* L. Sp. Pl. 908. 1753; *C. leucanthema* L. Amoen. Acad. **4**:291. 1759; *Bidens dondiaefolia* Less., Linnaea **5**:155. 1830.[21]

In a former article (SHERFF, BOT. GAZ. **64**:32. 1917), I stated reasons for believing that *Bidens dondiaefolia* Less. was synonymous with *Coreopsis alba* L. Recently I have found LESSING's type (Herb. Univ. Halle). That plant matches exactly the MUELLER specimen (no. 148, Herb. N.Y. Bot. Gard.) formerly cited by me, thus confirming very definitely my earlier treatment.[22]

[20] We may mention also the name *Leidon mite* (Michx.) Shuttl., which was printed on RUGEL's label for a specimen of this species (Herb. Berl.), with *Coreopsis mitis* Michx. cited as a synonym.

[21] Numerous other synonyms must be omitted here.

[22] It may be added that in recent years studies have convinced me conclusively that *Coreopsis alba* L. and *C. leucanthema* L., both of them really *Bidens*, were synonymous and to be referred to varietal rank under *Bidens pilosa* L. While many botanists (O. E. SCHULZ, OTTO HOFFMANN, etc.) have already employed this varietal rank for the radiate plant in question, it appears that SCHULTZ BIPONTINUS was the first to do so, using the name *radiata*.

BIDENS JACKSONII (S. Moore), comb. nov.; *Coreopsis Jacksoni* S. Moore, Jour. Linn. Soc. **35**:347. 1902; *Bidens spathulata* Sherff, BOT. GAZ. **76**:149. *pl. 13.* 1923.

My recent examination of the type specimen of *Coreopsis Jacksoni* S. Moore (Herb. Brit. Mus.) showed that it was merely a tiny, dwarfed specimen (*cf.* Moore, *l.c.*, "unfortunately a mere scrap") of the species described and illustrated by me under the name of *Bidens spathulata*.[23] Because, however, of its very diminutive stature (being only a few centimeters high), it lacked the spathulate type of leaves that so strongly characterizes larger plants. The leaves were more rotund in outline. For these reasons, MOORE's description of *Coreopsis Jacksoni* was, of necessity, so misleading that only a personal study of his type plant could impart an understanding of its specific status. As to its generic status, its complete lack of mature achenes, as also in the case of the type of *Bidens spathulata*, makes it necessary to rely upon general habit, which is more that of *Bidens* than of *Coreopsis*.

BIDENS PILOSA L. Sp. Pl. 832. 1753; *B. reflexa* Link Enum. Hort. Berol. **2**:306. 1822.

The name *Bidens reflexa* Link has been variously construed by botanists during the past century. This is doubtless due to the fact that more than one species of plant was obtained in European botanical gardens from supposedly *Bidens reflexa* achenes which had been sent out from Berlin. Thus, some of the *B. reflexa* material in the Berlin Herbarium is *B. pilosa* L., while in the Herbarium of the University of Halle, for example, a specimen labeled "*Bidens reflexa* Hort. bot. Berol." is really *B. grandiflora* Balb. Fortunately, however, there exists in the Berlin Herbarium an original specimen by LINK himself. Its main label says, in pencil, "*Bidens* sp. Mexico." In ink is written, further, "*reflexa* m. (Link)." Another label says, "*Bidens reflexa* Link En. 2. p. 306. Hort. Bot. Berol." This specimen is clearly of LINK's type material, and matches his description, except that he erred in calling it a perennial, for it is an annual. It is nothing more than plain *B. pilosa* L., to which it must be referred.

BIDENS TRIPARTITA var. REPENS (D. Don), comb. nov.; *B. repens* D. Don Prodr. Fl. Nepal. 180. 1825; *B. trifida* Buch. in Roxb. Fl. Ind. Edit. II. **3**:411. 1832; *B. Taquetii* Lévl. *et* Vant. *in* Lévl., Bull. Acad. Internat. Geogr. Bot. **20**:3. 1910; *B. minuscula* Lévl. *et* Vant. in Lévl., *l.c.*—Saepius tantum 1–4 dm. alta, foliis nunc simplicibus et anguste lanceolatis, nunc tripartitis segmentis anguste lanceolatis vel saepe cuneato-lanceolatis. Achaenia cuneato-linearia, brunneo-subnitida vel subnigra, marginibus laevia vel aegre retrorso-hamosa,

[23] The type of *Bidens spathulata* was collected upon Mt. Kenia, British East Africa. The type of *Coreopsis Jacksoni* was collected in the small Kikuyu area immediately to the southwest.

corpore plerumque 5–8 mm. longa, apice 2- vel 3-aristata aristis retrorsum hamosis.

Bidens Taquetii Lévl. et Vant. and *B. minuscula* Lévl. et Vant. were described from specimens collected by TAQUET in Corea. *B. Taquetii* (*Taquet* 1035) is described as having radiate heads, the ligules being 3-striate. The several cotypes examined by me (Herb. Kew, Herb. Berl., etc.) uniformly lack rays, but even were tiny rays present they alone could not be of conclusive value in diagnosis, since true European *B. tripartita* has been known for many years to produce, in rare cases, small rays. *B. minuscula* (*Taquet* 1031) is merely a dwarfed form of *B. Taquetii*. Its several cotypes studied by me (Herb. Berl., Herb. Kew, Herb. Univ. Munich) excel, however, in having mature achenes. These have the slender, cuneate-linear, often almost glossy bodies with smooth margins, met with in a number of specimens from the Orient. Quite generally in herbaria this far-eastern form has been referred to *B. tripartita*. The dwarfed plants of it, however, do not resemble the dwarfed plants of *B. tripartita* commonly found, for example, in Europe. Rather do they have slender, oblanceolate leaves. Among the larger plants, however, various intergradations in foliage are found, particularly in Japan and Formosa, between the form of the Orient and the one typical in Europe. We have also the fact that in the particular oriental form under discussion the smooth margins of the achenes are strikingly different from the spinulose margins of normal *B. tripartita* achenes. In view of these considerations, it seems wisest to treat the TAQUET plants as representing a geographic variety.

Reference to literature shows that long ago this eastern form was listed for Nepalia (India) by ROXBURGH, who published the manuscript name *B. trifida* previously given it by BUCHANAN, and gave a full description. ROXBURGH'S description of the achenes ("flat, wedge-shaped, smooth, without angles; horns two, rarely three, backwardly hispid, diverging") is significant.

In the British Museum of Natural History are two old sheets, labeled in pencil, "*B. repens* Don." The plants are similar to the cotypes of *B. Taquetii* Lévl. et Vant., and match the description of *B. trifida* Buch. *ex* Roxb. They match also DON'S earlier but less ample description, published in 1825, of *B. repens*. At least one plant was collected by WALLICH, likewise in Nepalia, and bears WALLICH'S list no. 3187*a*. DON'S text included plants "*a D. Wallich nuperius missae*," and it is probable that he had seen these sheets before publishing his description of *B. repens*. In any case, however, his description rested primarily, as did ROXBURGH'S, upon the material collected by BUCHANAN[24] in Nepalia, and thus, with *B. repens* Don, *B. trifida* Buch. *ex* Roxb. is seen to be synonymous.[25]

[24] Known in literature also as FRANCIS HAMILTON (*cf.* DON, *l.c.*; Alph. DC. Phytogr. 418. 1880.)

[25] *V. Komaròv* (=*L. V. Komarow*) 1535, collected along the Mu-dan-dsian River, Province Kirinensis, Manchuria, September 19, 1896 (Herb. Berl., Herb. Brit. Mus., etc.) is a small slender mud form with elliptic or oblong-lanceolate leaves, and achenes

BIDENS TRIPARTITA var. ORIENTALIS (Velen. *ex* Bornm.), comb. nov.; *B. orientalis* Velen. *ex* Bornm., Bot. Centralbl. **36**:61. 1888 (*nomen*); Velen. in Sitzb. Boehm. Ges. Wiss. **1888**:48. 1889; Fl. Bulg. 250. 1891.—Var. achaeniis parvis, obovato-cuneatis, planis, nitidis, purpureo-nigris vel saepius nigrescentibus, ad margines retrorsum tuberculato-hamosis, alibi glabris vel versus apicem sparsissime pilosiusculis, corpore exterioribus 4–4.5 mm. longis et 2.2–2.5 mm. latis interioribus circ. 4.5 mm. longis et 1.5–2 mm. latis, omnibus biaristatis vel saepe imperfecte triaristatis, aristis retrorsum hamosis, duabus principalibus circ. 2 mm. longis.

The most distinctive feature of the several specimens examined from the type region is the small, often black achenes. Numerous intergradations between these and typical *B. tripartita* achenes are found in European material, however, nor in any other characters can I find sufficient constancy to warrant specific segregation from *B. tripartita* L. Evidently it is more logical to rank these small-fruited extremes, especially common in Bulgaria and Servia, as a variety of *B. tripartita* L.

BIDENS TRIPARTITA var. HIRTA (Jord.), comb. nov.; *B. bullata* L. Sp. Pl. 833. 1753; *B. hirta* Jord. in Gren. *et* Godr. Fl. Fr. **2**:168. 1850; *B. tripartita* sub-var. *rugosa* Coss. *et* Germ. Fl. Par. edit. II. 487. 1861; *B. bullata* var. *hirta* (Jord.) Coste Fl. Fr. **2**:357. 1903; *B. fastigiata* var. *hispida* Car. et St.-Lag. Et. fl. 459, *fide* Rouy Fl. Fr. **8**:219. 1903; *B. tripartita* var. *genuina* sub-var. *rugosa* Coss. et Germ. in Rouy *l.c.* 218; *B. tripartita* subsp. *bullata* (L.) Rouy and subsp. *bullata* var. *hirta* (Jord.) Rouy *l.c.* 219; *B. bullata* vars. *typica* and *glabrescens* Fiori Fl. Anal. **3**:302. 1904.

LINNAEUS presented a rather distinctive description of his *Bidens bullata*, but gave its habitat as in America. The single well preserved specimen in the Linnean Herbarium matches the original description very closely. There can be no doubt at all that LINNAEUS drew his description either from this specimen or from another identical with it. However, the plant is seen at once to be a European form, entirely unknown from America or any other continent than Europe. The plate of *B. bullata* published by HARDUIN (Animadv. Bot. *pl. 18.* 1764) differs in no important respect except that the principal leaves are undivided, instead of being tripartite with the lateral lobes small and inconspicu-

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moderately retrorse-hooked on margins. It was distributed under the name *B. tripartita* var. *limosa* Komarôv. The plant is an intermediate form between our var. *repens* and the species proper.

ous, as in LINNAEUS' specimen. The various herbarium specimens distributed by JORDAN from the vicinity of Lyon, under his name *B. hirta*, have the leaves undivided, but certainly cannot be said to differ consequentially from LINNAEUS' plant. In fact, other specimens have been collected in the same locality that have the leaves tripartite, just as in the Linnaean plant (e.g., *Boullu* 310). The variation in the amount of roughness is likewise considerable. In view of this variation in leaf division and in amount of roughness, there can be no question that the plants of LINNAEUS and of JORDAN are specifically identical.

On the other hand, these plants are connected by many apparently freakish specimens[26] with *Bidens tripartita*, and doubtless are to be regarded more accurately as a rather well marked foliage form of that species. ROUY (*l.c.*) appears to have come to a similar conclusion, but his adoption of subspecific rank for *B. bullata*, and his making of *B. hirta* a variety of the subspecies are too unconventional to secure wide acceptance. It happens, however, that COSTE (*l.c.*) definitely published the name *hirta* as a variety, although under the species *B. bullata*(!).[27] In this curious way the name *hirta* was the first to receive publication with varietal rank, and, under the Vienna Code, must be adopted instead of *bullata*.

It may be noted that the Abbé BOULLU, whose collections of this variety extended over more than thirty years, paid particular attention to the matter of variation in its leaves. Finding various forms intermediate between *B. hirta* Jord. and *B. tripartita* L., and having assumed that *B. hirta* as well as *B. tripartita* was a valid species, he suspected the intermediate forms of being hybrids.[28] In the genus *Bidens* hybridity is so rarely encountered that, in the absence of more positive evidence, the intermediate forms would seem best accounted for on the basis of ordinary variation. However, BOULLU described (Bull. Soc. Bot. Lyon. ser. II. **7**:6. 1889) two of these supposedly hybrid forms under the names *B. hirto-tripartita* Boullu (with leaves broad, often tripartite) and *B. tripartito-hirta* Boullu (with leaves narrow, but likewise often tripartite).

[26] Especially branches from more or less injured stems.

[27] The manifest unwillingness of so many writers to unite the names *hirta* and *bullata* as synonyms surely must have been because LINNAEUS erroneously cited America as the home of *bullata*, and, further, because they themselves had never seen the Linnaean Herbarium specimen. Had they seen this plant, they would have been quick to realize that it was positively the form found in Europe and nowhere else.

[28] "Dans la Flore de France de Gr. et God. il est dit des feuilles de cette espèec ovales, fortement dentées, ce qui semble exclure toute idée de division; or parmi les exemplaires qu j'ai récoltés prés de la Bourbre à Pont-de Chérui, bon nombre portent quelques feuilles bi ou tripartites tantôt dans le haut, tantôt dans la bas de la plante. J'ai trouvé là le *Bidens hirta* comme perdu dans une forêt de *B. tripartita* L., atteignant près de deux mètres de hauteur. Les sujets à feuilles divisées seraient-ils un produit hybride de ces deux espèces? Sur les pieds isolés que j'ai rencontrés en plusieurs autres lieux, je n'ai pas observé cette division des feuilles." (From a printed clipping attached to sheet in Herb., Boiss.)

For the first of these two names, ROUY (Fl. Fr. **8**:219. 1903) has proposed the name, x *B. Boullui* var. *subbullata;* for the second, x *B. Boullui* var. *subtripartita.*

COSSON and GERMAIN'S *B. tripartita* sub-var. *rugosa*, a plant found about Paris, is seen from its description[39] to belong to this variety. I find no authentic specimen in the large Cosson herbarium (in Herb. Paris), but the main herbarium at Paris has a specimen from the environs of Paris (Charenton, on the islands of the Seine River, collected in 1841) given by WEDDELL in 1848 and clearly the source of COSSON and GERMAIN'S sub-variety. It is a remarkably hispid-scabrous form. In fact, its extreme roughness had been noted by WEDDELL himself, for his label reads, "*Bidens tripartita* L. var. *B. rugosa.*" Evidently, then, the name sub-var. *rugosa* was later derived from this. COSSON and GERMAIN'S comment, "Assez commun," is doubtless inaccurate, for such extremely rough forms appear rare in the vicinity of Paris.

BIDENS ANGUSTISSIMA var. LINIFOLIA (Schz. Bip. *ex* Klatt), comb. nov.; *B. linifolia* Schz. Bip. *ex* Klatt, Flora **68**:203. 1885.—A specie differt foliis indivisis, saepius 1–2 mm. latis.

In a former paper (SHERFF, BOT. GAZ. **64**:34. 1917) I have discussed the status of this form, predicting that it would probably be found to be a simple-leaved state of *B. angustissima* H.B.K. Further examinations of material have shown that in no way can the two be regarded as separate species. However, it does seem best to accord the simple-leaved form the rank of a variety under *B. angustissima.* Only very seldom is material found in herbaria that is not readily referable to one or the other.

BIDENS ASYMMETRICA (Lévl.), comb. nov.; *Lipochaeta asymetrica* Lévl., Fedde Repert. Spec. Nov. **10**:122. 1911.

This species belongs in no way to the genus *Lipochaeta.* It is a close relative of *Bidens sandvicensis* Less., from which it differs, however, in having a larger proportion of simple leaves (at least in the type material), also achenes which are strongly contorted and which are glabrous on the lateral margins as well as the faces.

Bidens brasiliensis, sp. nov.—Herba perennis, erecta, simplex vel supra ramosa, plus minusve tomentosa, ±1 m. alta. Folia principalia sessilia, indivisa, rhomboideo-elliptica, utrinque sensim angustata, membranacea, molliter denseque tomentosa, acriter numerosis dentibus serrata, 6–9 cm. long et 2.5–4 cm. lata; folia ramorum linearia, minora. Capitula subnumerosa (±40), discoidea, florescentia ±8 mm. alta et ±6 mm. lata, demum cum fructibus circ. 1.3 cm.

[39] "Tiges et rameaux rugueux-scabres, parsemés d'aiguillons sétiformes courts. Feuilles ord. rudes-scabres."

longa et 1–2 cm. lata. Involucri glabrati bracteae exteriores 5–8, lineares, subacute indurato-apiculatae, 3–6 mm. longae, interiores lanceolatae 7–10 mm. longae. Paleae achaeniorum corpora aequantes vel superantes. Achaenia atra, linearia, tetragona, omnino 8- (quaque facie 2-) sulcata, glabra vel supra sparsissime erecto-setosa, corpore 1–1.3 cm. longa et circ. 1 mm. crassa, ad apicem erecto-setosa et biaristata, aristis calvis vel saepius 1–3 hamis minutis retrorsum hamosis, usque ad 2.3 mm. longis, interdum deficientibus.

Auguste de Saint Hilaire 1196, State of Minas Geraes, Brazil (1816–1821; type in Herb. Paris).

In general habit *B. brasiliensis* resembles simple-leaved plants of *B. Riedelii* Baker and *B. Chodati* Hassler. From the former it differs in its more numerous heads, its lack of ray-florets, its elongate, aristate achenes, etc.; from the latter it differs in its wider and more rhombic leaves, more numerous heads, smaller involucres with much more glabrous and less numerous bracts, etc. The type had been collected by SAINT HILAIRE in two portions representing separately the lower, leafy stem and the branched, fruiting top. Both of these are taken as the basis for the description.

Bidens nyikensis, sp. nov.—Herba, verisimiliter perennis, caule simplici forsan ramoso, angulato, glabro vel ad summam piloso, ±3 dm. alto. Folia petiolata petiolis ciliatis anguste alatis 2.5–3.5 cm. longis, petiolo adjecto 4–11 cm. longa, pinnata, 3–5-partita, foliolis parce membranaceis, late linearibus vel rhomboideo-lanceolatis, 0.2–1.8 cm. latis, integris vel 1–2-lobis lateralibus instructis, margine revolutis spinuloso-ciliatisque, omnibus segmentis apice acutis. Capitula solitaria, terminalia, moderatim pedunculata pedunculo piloso usque ad 6 cm. longo, radiata, pansa ad anthesin ±3 cm. lata et ±9 mm. alta. Involucri hispidi bracteae exteriores circ. 8, moderatim vel late lineares, apice subacutae, 7–9 mm. longae et 1.2–2 mm. latae, interiores lanceolatae circ. 9–11 mm. longae. Flores ligulati circ. 8–10, flavi, tantum immaturi visi. Achaenia atra, linearioblonga, obcompressa, duabus faciebus non nisi ad summam hispida sed quaque circ. 8 sulculis lineata, margine apiceque valde erecto-ciliata, corpore 6.5–8.5 mm. longa et 2–2.7 mm. lata, biaristata aristis tenuibus, supra sparsissime infra saepe dense erecto-hispidis, 2–3 mm. longis, palearum apices coloratos parce superantibus.

A. Whyte 191, at altitude of 6000–7000 feet, Nyika Plateau, British Central African Protectorate, June, 1896 (type in Herb. Kew).

BIDENS RUWENZORIENSIS (S. Moore) Sherff, BOT. GAZ. **59**:309. 1915; *Coreopsis ruwenzoriensis* S. Moore, Jour. Linn. Soc. **35**:345. 1902.

The type, *G. F. Scott Elliot* 7410, was stated by MOORE to have been collected at Mt. Ruwenzori, but the original field-tag on the cotype at Kew gives, as the type locality, Kavirondo, some 400 kilometers to the east.[30] Both the type (Herb. Brit. Mus.) and the single cotype (Herb. Kew) consisted merely of fragments from the inflorescence. Thus the original description was necessarily very faulty and misleading as to general habit, size of leaves, etc. Fortunately, there have been received at Kew several additional specimens from the same general region: *A. Whyte*, from Nandi to Mumias etc., British East Africa, in 1898, 3 sheets; *J. D. Snowden* 28, at altitude of 4700 feet, Kyaka, Toro, Uganda, Brit. E. Afr., in 1913; *W. Small* 1192, short-grass land, foothills of Mt. Elgon at altitude of 5000 feet, Brit. E. Afr., November, 1914. These show the species to be a tall, handsome perennial, doubtless reaching a height of 2 meters, although SMALL reported it as growing 2–3 ft. As the mutual identity of all these specimens admits of no doubt, I have taken advantage of them to draw up a fresh and amplified description of the species:

BIDENS RUWENZORIENSIS (S. Moore) Sherff, descript. amplific. —Herba erecta, elata, verisimiliter 0.6–2 m. alta, caule glaberrimo vel ad summam interdum minute pubescenti, ramis validis, teretitetragonis, adscendentibus. Folia sessilia, per paria plus minusve connata, oblonga vel oblongo-oblanceolata, firme membranacea, albido-virescentia vel glaucescentia, glabra vel faciebus obscure pubescentia et margine ciliata, subgrosse subsimpliciterque serrata dentibus saepius indurato-apiculatis, principalia 10–13 cm. longa et 3–4.5 cm. lata. Capitula magna ramulos singillatim coronantia, radiata, pansa ad anthesin plerumque 7–8 cm. lata et 1.5–2 cm. alta. Involucri bracteae 3-seriatae, glabrae vel minute pubescentes, extimae (circ. 5) ovato-lanceolatae, foliosae et interdum sparsissime denticulatae, apice subacutae, usque ad 3 cm. longae et 1.5 cm. latae; interiores manifeste breviores, lanceolatae, margine non decoloratae. Flores ligulati circ. 12, lutei, ligula anguste ovato-oblongi, apice undulati vel circ. 3-denticulati, 2.3–3.5 cm. longi et 1–1.5 cm. lati; paleis lineari-lanceolatis, achaenia facile superantibus, 1–1.5 cm. longis. Achaenia atra vel atro-grisea, maxime obcompressa, oblonga, basi levissime angustata, margine apiceque erecto-

[30] The name *ruwenzoriensis* was not entirely inappropriate, however, since Mt. Ruwenzori was Elliot's destination, and his herbarium labels do in fact bear the heading, "Ruwenzori Expedition."

setosa, duabus faciebus plus minusve erecto-setosa et quaque circ. 8-sulcata, corpore 6–9 mm. longa et 1.8–2.3 mm. lata, biaristata; aristis tenuibus, maximam partem nudis sed versus basim 1–3 setulis erectis instructis, 1.5–2.8 mm. longis.

BIDENS CORIACEA (O. Hoffm.), comb. nov.; *Coreopsis coriacea* O. Hoffm., Engler Pflanzenw. Ost-Afr. 414. 1899.

The type (Herb. Berl.) was collected by FISCHER, no. 367, Massai Plateau, British and German East Africa, March 26–30, 1886. It consists of seven small fragments from the inflorescence. These offer a superficial resemblance to *Bidens ruwenzoriensis*. Indeed, S. MOORE (Jour. Linn. Soc. **35**:345. 1902) appears to have suspected the possible identity of the two species. In *B. coriacea*, however, the outermost involucral bracts, as noted by MOORE, are not noticeably longer than the inner ones, and the achenes are mainly triaristate. In *B. ruwenzoriensis* the outermost bracts are easily the longest and the achenes are biaristate. Apparently it is wisest to await further specimens of *B. coriacea* from Massai before trying to equate the two species.

Bidens Rogersii, sp. nov.—Herba perennis, erecta, glabra, simplex forsitan ramosa, ±5 dm. alta. Folia petiolata petiolis alatis 0.5–3 cm. longis, petiolo adjecto 4–8 cm. longa, pinnatim 3–7-partita, foliolis crassiusculis, margine revolutis et sparsim ciliatis, linearibus, lateralibus usque ad 5 cm. longis, terminali elongato usque ad 7 cm. longo, omnibus integris vel pinnatisectis dentibus (lobulis) linearibus patentibus. Capitula solitaria, longe pedunculata, forsitan radiata (nullis ligulis visis), involucro ad anthesin ±2.3 cm. lato et ±1.1 cm. alto. Involucri bracteae aequilongae, exteriores circ. 8, lineares, infra hispidae, apice acutae, 0.9–1.2 cm. longae; interiores ovato-lanceolatae, margine decoloratae, dorso glabratae vel parce hispidae. Achaenia submatura nigrescentia, lineari-oblonga vel lineari-oblanceolata, valde obcompressa, quaque facie circ. 8-sulcata, margine apiceque valde faciebus aegre erecto-setosa, corpore 6–8 mm. longa et 1.8–2.2 mm. lata, biaristata; aristis tenuibus, calvis vel sparsim erecto-setosa, 2–3 mm. longis.

Rev. *F. A. Rogers* 10046, Sakania, Belgian Congo, August 18, 1911 (type in Herb. Kew).

BIDENS SCHIMPERI **leptocera,** var. nov.—Herba erecta, ±6 dm. alta, verisimiliter annua, caule glabro, ramoso. Folia superiora (inferiora non visa) subsessilia, usque ad 6 cm. longa, bipinnatisecta segmentis linearibus vel lineari-lanceolatis, valde membranaceis,

sparsim hispidis, ciliatis, acriter dentatis, 1–5 mm. latis. Capitula tenuiter pedunculata pedunculis usque ad 6 cm. longis, radiata, pansa ad anthesin circ. 2.5 cm. lata et 6–8 mm. alta. Involucri bracteae moderate hispidae, exteriores 5–8, lineares, acriter induratoapiculatae, 3–6 mm. longae, interioribus ovato-lanceolatis parce longiores. Flores ligulati probabiliter circ. 8 (in uno capitulo imperfecto tantum 5 observati), lutei, ligula elliptico-oblanceolati, apice obscure denticulati, circ. 8–10 mm. longi. Achaenia parva valde obcompressa, ovato-oblanceolata vel lineari-oblonga, exalata, atra vel atrofusca, quaque facie circ. 8-striata, marginibus erecto-ciliata, faciebus erecte plus minusve spinuloso-setosa, apice setis erectis valde et perspicue coronata, corpore tantum 3–4.5 (rarissime –5) mm. longa et 0.8–1.1 mm. lata, biaristata; aristis perspicue tenuibus, leviter arcuatis, solum apice retrorsum hamosis, 1.5–3 mm. longis.

C. F. M. Swynnerton 845 A. Kilossa, German East Africa, May 8, 1921 (type in Herb. Brit. Mus.).

Many species of *Bidens* are polymorphic as to foliage, and yet reasonably constant as to characters of flower and fruit. *B. Schimperi* (Pl. III), however, offers an amazing range of variation in all respects. Thus, in typical *B. Schimperi* the external bracts of the involucre become 10–17 mm. long, but in forms of the species (of which *B. acutiloba* Sherff must be considered one) these may become only 3–6 mm. long. Again, in typical material, the achenial bodies range in length from 0.9–2.2 cm., while in various forms these range as low as 3–6 mm. long. OLIVER and HIERN, also OTTO HOFFMANN, in their work on the African flora, came to recognize a large number of these forms as merely variations of *B. Schimperi*, although to a novice these would seem separate species. In most cases it appears unwise to attempt here any segregation of these forms as varieties. The plant collected by SWYNNERTON is unique in so many respects, however, that it is thought best to give a full description and distinct varietal treatment.

Bidens speciosa Gardn. in Hook. Lond. Jour. Bot. **4**:126. 1845; *B. pallida* Rusby, Bull. N.Y. Bot. Gard. **4**:389. 1907.—Pl. IV.

Bidens pallida Rusby was founded upon *Miguel Bang* 2152, Coripati, Yungas, Bolivia, April 25, 1894 (Herb. Boiss.; Herb. Brit. Mus.; Herb. Copenh.; Herb. Deless.; Herb. Kew; Herb. Mo. Bot. Gard.; Herb. N.Y. Bot. Gard., type; Herb. Mus. Vienna; Herb. Univ. Vienna, etc.). The specimens were somewhat immature, but they are seen to be merely a foliage form of *B. speciosa* Gardn., a

species close to *B. squarrosa* H.B.K. and very common in Brazil, although in rare cases it has been found elsewhere (*Scherzer* 853, alt. 9100 ft., San José, Costa Rica, September–November, Herb. Mus. Vienna; *José Steinbach* 5584, Orilla del bosques, alt. 400 m., Rio Surutú Buena Vista, Province Sara, Dept. Santa Cruz, Bolivia, April 15, 1921, Herb. Deless., Herb. Field Mus.).

CHICAGO NORMAL COLLEGE
CHICAGO, ILL.

EXPLANATION OF PLATES I–IV

PLATE I

Bidens Moorei: a, flowering and fruiting branch, ×0.68; *b*, exterior involucral bract, ×1.36; *c*, interior involucral bract, ×2.72; *d*, ligule, ×1.36; *e*, palea, ×2.72; *f*, disc floret, ×2.72; *g*, achene, ×2.72; *a–g* from *Gossweiler* 3339, type, in Herb. Brit. Mus.; *B. Moorei* var. *verrucosa; h*, *i*, achenes, ×2.3, from *Gossweiler* 3021, type, in Herb. Brit. Mus.

PLATE II

Bidens urophylla: a, flowering and fruiting branch, ×0.66; *b*, exterior involucral bract, ×5.3; *c*, interior involucral bract, ×5.3; *d*, ligule, ×5.3; *e*, palea, ×5.3; *f*, disc floret, ×5.3; *g*, achene, ×5.3; all from *Martius*, near Mariana, Minas Geraes, Brazil, type, in Herb. Univ. Munich.

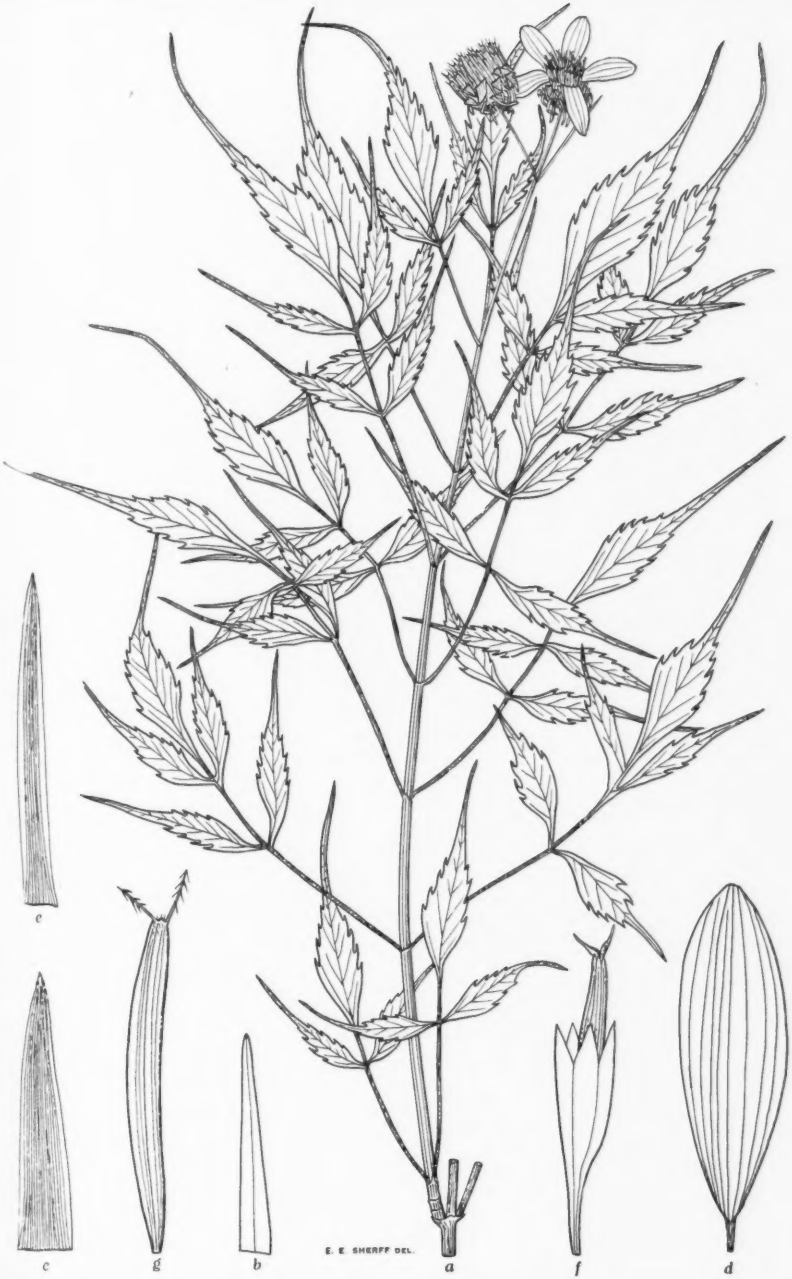
PLATE III

Bidens Schimperi (forms of): *a*, *j*, flowering and fruiting specimens, ×0.64; *b*, portion of leaf from *a*, ×3.2; *c*, *k*, exterior involucral bracts, ×3.2; *d*, *l*, interior involucral bracts, ×3.2; *e*, *m*, ligules, ×3.2; *f*, *n*, paleae, ×3.2; *g*, *o*, disc florets, ×3.2; *h*, *p*, outer achenes, ×3.2; *i*, *q*, inner achenes, ×3.2; *a–i*, from *Volkens* 384, type of *Bidens acutiloba*, in Herb. Boiss.; *j–q*, from *Schilling* 67, Kilimanjaro district, Africa, in 1903, Herb. Berl.

PLATE IV

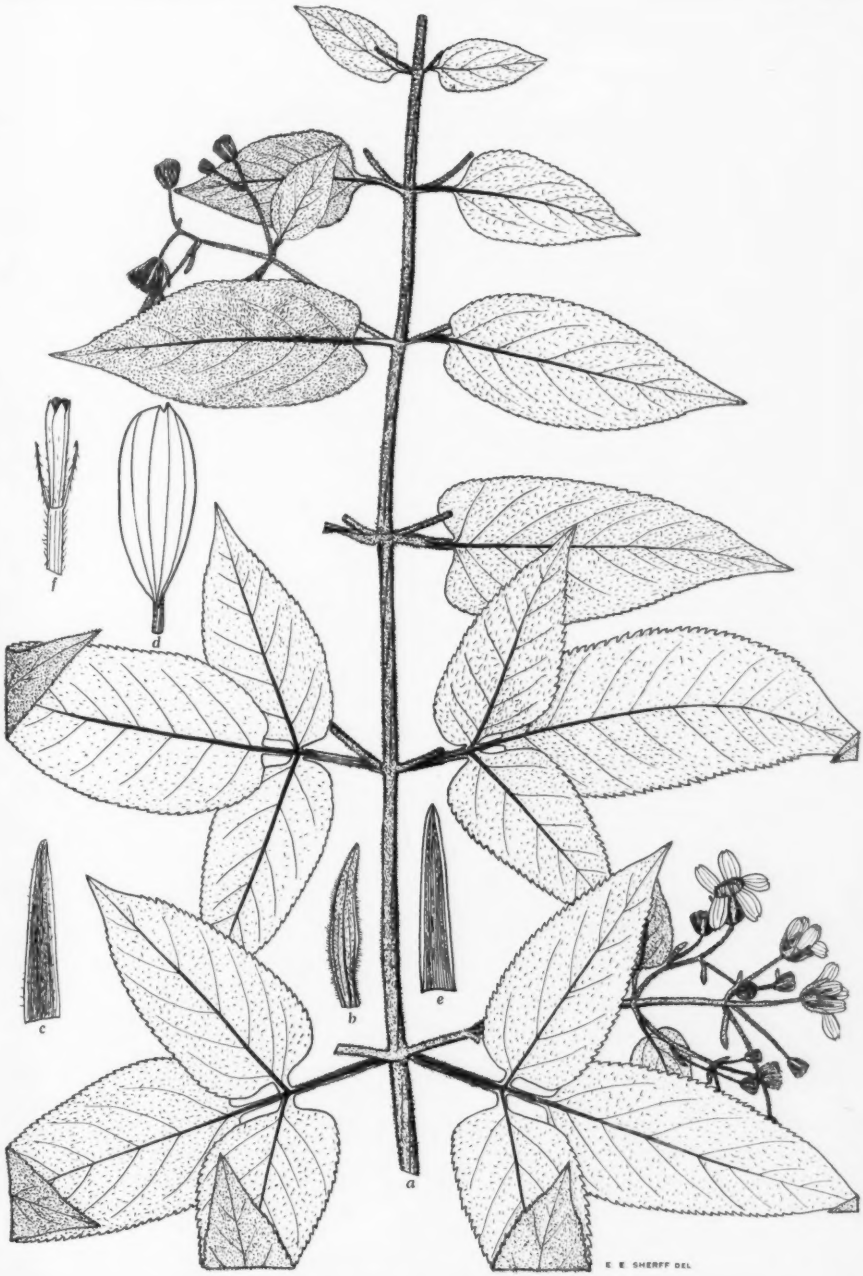
Bidens speciosa (form of): *a*, portion of flowering branch, ×0.65; *b*, exterior involucral bract, ×3.3; *c*, interior involucral bract, ×3.3; *d*, ligule, ×2.6; *e*, palea, ×3.5; *f*, disc floret, ×3.5; all from *Bang* 2152, mainly the (type) specimen in Herb. N.Y. Bot. Gard.

SHERFF on BIDENS



SHERFF on BIDENS

SHERFF on BIDENS



SHERFF on BIDENS

ORIGIN OF CLEAVAGE POLYEMBRYONY IN CONIFERS[1]

JOHN T. BUCHHOLZ

(WITH PLATES V–VII AND TWO FIGURES)

Polyembryony and developmental selection

Polyembryony, as it occurs in gymnosperms, is the expression of a peculiar form of developmental selection. There are two forms of polyembryony with respect to the origin of the embryos: simple, due to the fertilization of several eggs; and cleavage, due to the splitting of the product of the individual zygotes.

In some conifers, such as *Pinus* (figs. 4, 6, 12), *Tsuga* (fig. 11), *Cedrus* (fig. 20), and *Libocedrus* (figs. 23, 24), cleavage polyembryony can be recognized both by counting the number of embryos produced from each zygote, and by tracing each embryo back to a single celled suspensor. Simple polyembryony is illustrated by *Abies* (fig. 7), *Picea* (fig. 21), *Larix*, and *Pseudotsuga* (fig. 14), where the suspensor is made up of four or more collateral elongated cells which may be traced back to the same archegonium, and there are usually only as many embryos as there were fertilized eggs. In all instances this polyembryony results in a struggle for existence within the developing seed (embryonic selection), in which sometimes only two or three, sometimes as many as thirty or forty, very young embryos are in competition. In this struggle, the embryo possessing the greatest growth activity soon gains an advantage, usually represented by its foremost position with respect to its competitors, and it eliminates all of them sooner or later, for practically always only one embryo remains in the mature seed. The elimination usually takes place in the earlier stages of development, so that by the time the largest embryo has begun to organize its cotyledons, there are only very small traces of the checked embryos remaining. Frequently the successful embryo may be recognized at an early stage, as the one foremost in position; soon it is the largest and comes to

[1] Research paper no. 33, Journal Series, University of Arkansas.

possess a longer and more multicellular suspensor than any of its competitors. In this elimination, chance plays a minor rôle, for the persisting embryo usually merits this reward. This is a conclusion based upon observations on a large series of embryos of different conifers, dissected out in various stages of development. It seems clear from such studies that the embryo possessing the greatest growth vigor usually wins in the competition. The more speedily an embryo becomes multicellular and of larger diameter than its neighbors, the sooner will it be able to push out a stiff multicellular suspensor, which is sometimes equipped with hooks or spurs formed by many outwardly projecting embryonal tubes (fig. 24). This suspensor is in reality an organ of competition; it is the structure by means of which the eliminated embryos are pushed back toward the micropyle, where they become starved and crushed.

The values measured by embryonic selection, expressed mainly as variations in their growth rate, represent differences which are inherent among the several embryos. These differences may have their origin in a chromosomal re-assortment of hereditary qualities during the first few cell divisions of the zygote, as was observed by HUTCHINSON (5) in *Abies*, or they may be due to inherent differences among the several zygotes, where embryos from several eggs enter into the competition.

In conifers, this developmental selection often measures more than the differences between the embryos, for it really consists of a relay race. The successful embryo plus the pollen tube which produced it must be superior to the sum of the pollen tube and embryo of its neighbors within the same ovule. Where cleavage polyembryony is involved, the competition measures the best pollen tube plus the best fraction of its zygote, against many other similar combinations within the same developing seed.

Direction of evolution of cleavage polyembryony

Some light is thrown on the nature of cleavage polyembryony by considering the direction in which its evolution must necessarily proceed. Let us first consider the possible outcome if a plant having simple polyembryony should give rise to the condition of cleavage polyembryony. Could cleavage polyembryony originate and survive

under conditions as they exist within an ovule, as it must be assumed that it has in relatively recent time, if cleavage polyembryony is a feature of recent origin?

Suppose, for example, that in fig. 1, representing a condition similar to *Pinus*, cleavage polyembryony does not exist. Let *B* represent in this instance a condition in which the entire zygote forms the embryo, and in which the competition which exists is between *B* and *A*, or other neighboring zygotes. Let *A* represent a

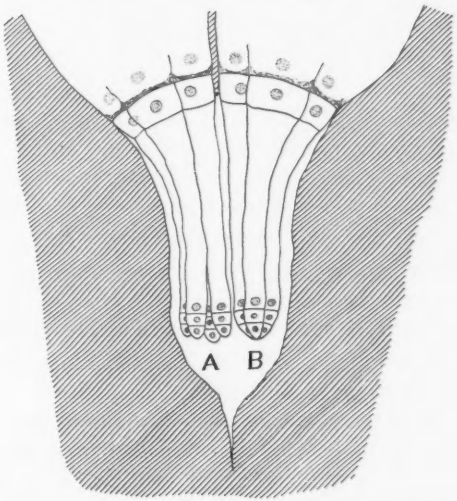


FIG. 1.—Two conditions in embryogeny (explanation in text).

departure from the usual condition, a change in which cleavage of the zygote is taking place. Under these conditions, what chance is there that any of the several embryos at *A* might survive? Judging by the available facts about the competition among conifer embryos, the answer is not difficult; there is little or no chance that any of the smaller embryos at *A* might survive. Granted that fertilization of the two eggs was simultaneous, and other conditions except cleavage polyembryony the same, since embryo *B* is so much larger than *A* to begin with, and since it starts its forward growth with a 4-celled and much more rigid suspensor (in fact it has in the number of its

cells a fourfold advantage over the embryos at *A*), there can be no doubt of its supremacy from the beginning. Embryo *B* will probably contribute the successful embryo to the seed, and the change to cleavage polyembryony in *A* will leave no progeny.

Suppose that *A* represents the usual condition, that to begin with cleavage polyembryony is present as shown here, and that a change from the condition in *A* to that in *B* has taken place. This time the change will survive, for the new condition *B* is the larger embryo, equipped with the stiffest suspensor, while the several units of *A* will lose out in the competition with *B*. Thus the new condition represented by *B* would survive the embryonic competition to produce the seed germ, and certainly it would leave a progeny, which could continue and establish this characteristic of simple polyembryony, although its derivation was from a condition of cleavage polyembryony. It is therefore not likely that cleavage polyembryony has had its genesis in relatively recent times, but rather that this condition had its origin possibly as early as the time of the origin of seeds themselves. At least it must have appeared before the mechanism of developmental selection reached its present adjustment; before the combined activities of pollen tubes plus their respective whole embryos from separate zygotes were pitted against each other in the decisive internal competition which exists within the ovules of conifers. It seems clear to the writer that embryonic selection would permit evolution to proceed from cleavage polyembryony to simple polyembryony, but not in the reverse direction.

The evolution of simple polyembryony from cleavage may be considered a kind of orthogenesis, but one which can be explained on a mechanical basis; it is a question of embryonic selection. A very definite product of this orthogenetic mechanism is a very large suspensor, which is certainly an over developed structure when we consider the structure and function of suspensors generally in other seed plants, where embryonic selection is not usually found.

Failure of simultaneous fertilization

It follows from the nature of this developmental selection, that the origin of cleavage polyembryony is to be sought under conditions in which only a single egg was fertilized, or in which the fertili-

zation of several eggs was not simultaneous or nearly so, with the result that the embryonic selection did not eliminate the smaller products of cleavage. This condition of successive rather than simultaneous fertilization would protect the much smaller and weaker embryos coming from the cleavage of an early zygote. Either of at least two conditions could have brought about successive fertilization or failure of simultaneous fertilization. Both have to do with the necessary conditions existing at the beginning of siphonogamy, and both may have played an important part at this stage in the origin of cleavage polyembryony.

Transition to pollen tubes

The first of these conditions which could preserve cleavage polyembryony against the odds of elimination through embryonic selection has to do with the change from fernlike microgametophytes to pollen tubes. It would seem probable that during the earliest stages of pollen tubes, when these male gametophytes were for example in a state of transition from that of heterosporous ferns to the condition found in pine, these pollen tubes were not equally able to grow in the sporophyte tissue. With free swimming sperms, as occurring in ferns, simultaneous fertilization of several eggs was the usual condition which initiated the process of embryonic selection, but with the change to pollen tubes, one would expect that simultaneous fertilization of two or more eggs would be only rare and very accidental.

The time of fertilization of neighboring archegonia probably varied by weeks or months, where this varies today in living forms by only days or hours. This interval of difference in growth rate of several relatively imperfect pollen tubes was the occasion for the survival of cleavage polyembryony, should it have originated either as a new mutation or in a segregation following some kind of hybridization.

The second of these conditions is suggested by a fragment of paleontological evidence. It also has to do with the beginnings of siphonogamy. Let us consider the seed of *Cordaianthus* as described by RENAULT (fig. 2). Here the nucellus is shown with a narrow passage which leads down to a pollen chamber; the microspores

are found wedged in this passage. Remembering that in *Pseudotsuga* and some other gymnosperms the pollen normally germinates in such a micropylar passageway, one can readily see that if a form similar to *Cordaianthus* should change to siphonogamy with such a disposition of structures, only one pollen tube at a time could function. The upper pollen grain is so much farther from the eggs than the lower one to begin with, that an equal length of these pollen tubes could not effect a simultaneous fertilization of the eggs in several separated archegonia. Whether the microspores begin to germinate in the micropylar passage or within the pollen chamber which is usually found below, their distances from the various archegonia are practically certain to be unequal. Thus the zygote resulting from the first fertilization might undergo cleavage, and the resulting smaller embryos become large enough to win out in competition against a later zygote having no cleavage, even though the second is a much larger embryo, one derived from an entire egg.

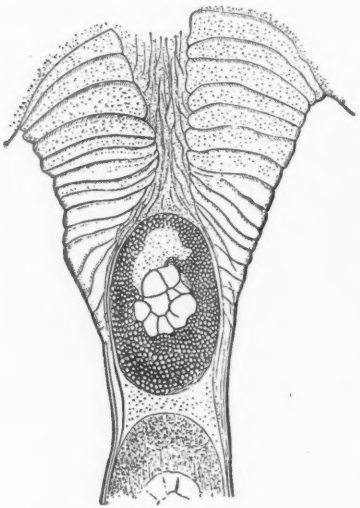


FIG. 2.—*Cordaianthus Grand'Euryi:* section of beak of nucleus; wedged in passageway are two large pollen grains, lower one showing part of surface of exine, and also multicell ularinterior; ×225 (from COULTER and CHAMBERLAIN, after RENAULT).

The seed of the form from which conifers were derived may have differed from that illustrated by *Cordaianthus*. There is no doubt, however, that the mechanism involved would be very similar in any megasporangium in which the microgametophytes became penetrating digestive structures. Whether the change was wrought by the one alternative or the other is of little importance; the stress should be placed on the fact that the newly formed pollen tubes did not effect fertilization of the eggs simultaneously. It is probable

that both of these conditions existed at this stage, and that both contributed in producing for a time a condition in which the several pollen tubes did not simultaneously fertilize the eggs of neighboring archegonia, thus permitting cleavage polyembryony to become an established feature of practically all primitive conifers, before they began yielding in their evolution to the mechanical tendency to return to simple polyembryony. This variability in the growth rate of pollen tubes would also serve to retain a species or an entire group in the condition of having cleavage polyembryony.

Cleavage polyembryony not recent

Considering the foregoing, it is difficult to explain how cleavage polyembryony could be a feature of recent origin. Orthogenesis, if we may be permitted to use this term in designating the mechanical tendency to pass into simple polyembryony, favors the elimination of cleavage polyembryony wherever pollen tube competition is effective enough. Cleavage polyembryony was therefore only an incidental event, accompanying or closely following the early advent of siphonogamy, and this is why many conifers have returned to simple polyembryony, especially in forms where the pollen tubes afford a competitive mechanism of a sufficient degree of perfection so that the fertilization of several eggs by competing pollen tubes is practically a simultaneous event.

Evidence from comparative embryogeny

The conclusion that cleavage polyembryony must have been a rather primitive condition, and one through which nearly all conifers have passed, was reached independently on morphological grounds. For example, in *Pinus* (1), which we regard as very primitive in its embryogeny, we have cleavage polyembryony associated with fern-like apical cell growth from the time of the first appearance of walls, but the apical cell usually disappears before the embryo cell mass contains 500 or more cells. In *Cedrus* and *Tsuga* we also have both cleavage polyembryony and apical cell growth, the latter apparently not for so late a period of development, although no adequate opportunities have permitted the writer to verify this point by means of serial sections. In *Picea*, *Larix*, and probably in *Pseudo-*

tsuga and *Abies*, there seems to be no normal apical cell growth at any stage, and here we usually have simple polyembryony. Thus in Abietineae, at least, cleavage polyembryony is associated with the fern type of apical cell growth in the earliest stages of embryogeny. From the writer's observations in Abietineae (**2**) it seems that both of these features were eliminated together. Among the other conifers usually regarded as less primitive, some have become specialized in the direction of cleavage polyembryony, and others by retaining apical cell growth. Probably some have retained both of these features in the embryo development, but exact knowledge of these details of conifer embryogeny is still very fragmentary.

Of course a primitive condition is frequently associated with advanced structures or conditions, and this mere association with the apical cell is not positive proof, but certainly the absence of apical cells among forms with cleavage polyembryony, and from the earliest stages (tracing each embryo back to a single cell of the proembryo), would constitute negative evidence. This negative evidence is absent, and to this extent at least we may utilize association of apical cell growth with cleavage polyembryony as suggestive of the primitive nature of the condition of splitting embryos.

The most convincing morphological argument favoring the primitive nature of cleavage polyembryony, however, comes from a study of the rosette embryos. These are the result of an extreme expression of cleavage polyembryony. The rosette cells in *Pinus*, for example, usually give rise to a group of four embryos, which send out suspensors; and in Abietineae, at least, the rosette embryos develop after the manner of the primary embryos by means of an apical cell. Figs. 6 shows an embryo complex representing the zygote from two neighboring archegonia. The eight primary embryos below have split apart as usual and are of good size, and in addition rosette embryos have developed from the rosette cells located at the base of the archegonia. In the group at the top to the right in fig. 6 (detail shown in fig. 25), several rosette embryos have pushed out suspensors which make them appear as very normal embryos. Were it not for their position with respect to the collapsed folds of the primary suspensor (*s*), these rosette embryos would easily pass for primary embryos. In the group of rosette embryos to the left (fig. 25 *re*) the

suspensors have not elongated, but all four of the rosette cells have undergone proliferation.

Fig. 3 represents a very much younger stage in *Pinus Laricio*, before the cleavage of the primary embryos has taken place. Fig. 4 is a stage in which the eight primary embryos from two zygotes may all be found. The rosette cells of one embryo system have not undergone development, but those of the other (*re* at the extreme left) have become multicellular. The latter are shown more highly magnified in fig. 5. Only in the later stages, such as figs. 4 and 6, do they grow out distinct embryonal tubes to form a suspensor, and frequently they abort in much earlier stages.

Even at their best, as in some species of *Pinus*, these rosette embryos are vestigial structures; they do not develop far. They are distinctly survivals from a condition of greater cleavage polyembryony. It is not probable that the rosette embryos in *Pinus*, or in any other conifer where they are found, ever contribute the embryo of the mature seed.

In *Cedrus* these rosette cells are usually persistent, and the rosette embryos frequently develop somewhat (figs. 16, 17), often becoming nearly as large as those of *Pinus* shown in fig. 4, but none were discovered with elongated suspensors. Figs. 18 and 19 illustrate well developed rosette embryos in *Cedrus libani*. *Cedrus* also has cleavage polyembryony, but the actual separation of the vertical rows of cells occurs only after one or two sections of embryonal tubes comprising the secondary suspensors have elongated quite fully. Fig. 16 shows such a stage in *Cedrus*, before cleavage has occurred among the primary embryos. In stages taken a week or ten days later, separation of the primary embryos had invariably taken place, resembling the *Pinus* embryos of figs. 4 and 6, and by this time a number of rosette embryos had usually begun to develop from the rosette cells. Fig. 20 is a single embryo of *Cedrus* on the end of a single celled secondary suspensor, after cleavage has occurred. A count of the number of primary embryos present in *Cedrus* at this stage, as well as the possibility of tracing the embryos back to their secondary suspensors of single embryonal tubes, easily distinguishes the embryo system of *Cedrus* as having cleavage polyembryony practically always, but with a distinct delay in the sepa-

ration of the embryos, as shown in fig. 16. That the development of the proembryo of *Cedrus atlantica* is practically identical with that of *Pinus* is indicated by the work of SMITH (9), who described and illustrated some of the stages.

In *Tsuga heterophylla*, as well as in *T. canadensis*, the rosette cells are found, but they abort early. They seem always to abort in the 1-celled stage without dividing further, although the separation of the four lower cells is a constant feature. Fig. 10 shows the rosette cells in an early stage of *T. canadensis*, and fig. 11 shows eleven of the primary embryos of *T. heterophylla* coming from three zygotes at a later stage. In the latter the rosette cells have collapsed so completely that they are difficult to demonstrate in a photograph, in fact they are not always easy to find in a preparation. Four primary embryos of *T. heterophylla* are shown in fig. 13.

In *Abies balsamea* the rosette cells are also found, sometimes as persistent nucleated cells (fig. 9). We agree with HUTCHINSON (6) that they are usually aborted, but in a count of 47 zygotes (of about the age shown in fig. 7) they were found in 12 per cent of the cases examined, where a clear view of the rosette was possible. This summary was made by counting the four vertical rows of cells separately, because frequently there were only one or two rosette cells which persisted in an embryo system, the other members of the rosette group having collapsed. Rosette cells were found more frequently in *Abies* than cleavage polyembryony. In 14 zygotes the rosette region was masked by the basal plate, and could not be observed satisfactorily. Only a few rare instances of rosette cells forming embryos were found in *Abies*. In fig. 8 the zygote to the right represents one of these, which is only 2-celled, and in the zygote to the left there are also a few undivided rosette cells. Usually the embryo presents the appearance shown in fig. 7, where the rosette cells have completely collapsed, and are represented only by their very thin walls, which may sometimes be found under high magnification.

While only 12 per cent of the rosette cells of *Abies balsamea* were actually persistent as living cells, in 40 per cent of the remaining cases their cell walls were discernible, although the protoplast had collapsed and often completely disintegrated. In the remaining

48 per cent of the cases, such little evidence of the rosette cells could be found that they might have been overlooked completely.

Abies alba also has rosette cells, according to SCHACHT (8), who shows three stages, all of them including the rosette cells, which do not appear to collapse as early as in *A. balsamea*. It is therefore certain that, except for the abortion of rosette cells, *Abies* and *Pinus* have homologous cells in the proembryo.

There is another point which should be mentioned in regard to an apparent difference between HUTCHINSON'S studies and those of the writer. HUTCHINSON studied only the stages as they were found in sections; the writer necessarily confined his efforts to the dissectible material at a slightly later stage. If some of the early embryos observed by HUTCHINSON abort and disintegrate completely, they might not be included with the dissected embryos of a slightly later stage. Judging from serial sections alone, HUTCHINSON found cleavage polyembryony somewhat more frequent than the writer, who used completely separated suspensors as the criterion of cleavage. Our findings are in substantial agreement concerning the main facts; the actual formation of rosette cells, whether they collapse very early or not, and in the usual non-occurrence of cleavage polyembryony.

In *Picea excelsa* (fig. 21), *P. mariana*, and *Larix europea* the rosette cells are formed, although they also collapse without forming rosette embryos in the material which was observed. They are difficult to demonstrate in embryos which have produced 3 or 4 sections of embryonal tubes, such as those of fig. 21. In a small percentage of cases, single nucleated rosette cells were found to hold over into stages of the age represented by fig. 21, but none of them were found developed to the 2-celled stage (fig. 22 illustrates the usual appearance of the collapsed rosette of *P. excelsa*). Only a single instance of a separation of primary embryos on the ends of embryonal tubes was observed among hundreds of embryos of *P. mariana* and *P. excelsa* which were examined.

Pseudotsuga has embryos without the rosette cells, as shown in figs. 14 and 15. Here the uppermost cells are the elongated suspensor cells, and no free nuclei were observed in the remains of the egg above these suspensors. The upper ends of the suspensors may be seen to

extend up into the base of the archegonium (fig. 15). In fig. 14 three embryos have come from three of the four or five archegonia, and no cases of splitting of these primary embryos were found. The three primary embryos are on their secondary suspensors (e_1), and were all bent slightly to one side in mounting.

In this series of embryos of the Abietineae, the outstanding feature is the gradual elimination of the rosette embryos. Even in *Pinus* they are vestigial, in *Cedrus* more so, and in the other forms the aborting initial cells represented by the rosette group are the last remains of the former rosette embryos. These aborting structures in *Larix*, *Picea*, or *Abies* could not be considered as having given rise to embryos in forms where cleavage polyembryony never existed, but reading the series in the other direction, they present clear evidence of reduction from 8-parted to 4-parted cleavage polyembryony with completely aborting rosette cells as in *Tsuga*, to simple polyembryony with rosette cells (or rarely the embryos) sometimes persisting as in *Abies*; and finally to forms illustrated by *Larix* or *Picea*, where only the last vestiges of these structures remain in embryos having no cleavage polyembryony. *Pseudotsuga* is the only member of this group which shows no rosette cells as anatomical evidence of having passed through a condition of cleavage polyembryony.

In a previous paper (3), the writer has demonstrated the normal existence of rosette cells in *Cephalotaxus*, and there seems to be similar evidence of such a reduction from cleavage polyembryony, sometimes involving rosette embryos in some other Taxineae and in certain Podocarpineae which will be described later.

In *Libocedrus*, which is included here because of its rather extreme illustration of cleavage polyembryony, the walled rosette cells are not found, according to LAWSON (7), and it will be seen (fig. 23) that a view of the rosette region is not favorable in the dissected preparations. *Libocedrus* is a form in which cleavage polyembryony is developed as a specialization. Since each of the 13 or more embryos may be traced back to single embryonal tubes or suspensor cells, there can be no doubt of the separation of the several zygotes in the production of this embryo complex. A more detailed account of the embryogeny of several Cupressineae will be given by the writer in another paper.

In *Cephalotaxus* (3) the deciduous cap at the tip of the embryo may have been involved in the elimination of cleavage polyembryony for the primary embryo, and if this is a result generally where caps are formed (although not necessarily the present function of this structure), it is possible that even Araucarians may have passed through a condition of cleavage polyembryony. Thus we may reasonably suppose that practically all conifers which do not show cleavage polyembryony have passed through this condition in the past, some of them reaching a point of embryonic organization in which all structural evidence of this feature is completely suppressed.

Rôle of cleavage polyembryony

There is one other fact or coincidence of some significance in this connection. It was previously pointed out by the writer (4) that several forms of developmental selection are usually, if not always, found in the reproductive life cycles of vascular plants. Table I

TABLE I

NATURAL SELECTION Environmental process occurring in external physical and biological environment of organism, where conditions of struggle for existence are very complex	Struggle against unfavorable environment of physical surroundings Struggle against other species; extraspecific competition Struggle against fellows; intraspecific competition
	Selection between vegetatively branching parts of either the gametophyte or sporophyte; buds and branches of trees, which later give rise to reproductive parts
DEVELOPMENTAL SELECTION Occurring during early embryonic or gametophytic stages within tissues of parent plant, under conditions uniform for competing individuals	Interovular selection, between ovules within same ovary: (1) after fertilization, largely due to activities of contained embryos; (2) before fertilization, due in part to activities of contained female gametophytes, megaspores, or archesporial cells Embryonic selection, between embryos within the same ovule, or within tissues of parent gametophyte Gametophytic selection: (1) between male gametophytes, such as pollen tubes within carpellary and nucellar tissue; (2) between female gametophytes within the same ovule Gametic selection: (1) between male gametes or sperms; (2) between female gametes or eggs

shows the interrelations of these forms of developmental selection and of these to natural selection.

A glance at the summary of table I makes it evident that most, or in fact nearly all of the more important or better understood forms of developmental selection were rendered ineffective in the transition to seeds at the time when free swimming sperms were no longer liberated in a drop of water connecting them up with several eggs. At this stage in the evolution of seed plants the megasporangia were not clustered and crowded close together as they are in the ovary of a flower, so that the interovular selection was probably not found. It is not even likely that a compact strobilus had been developed, for the examples of Cordaitales whose strobili have been found are all comparatively loose or open structures. The compound nature of the conifer cone itself clearly suggests a reduction from something more open and complex.

The restriction in the swimming range of the sperms occasioned by siphonogamy eliminated simultaneous fertilization, and when the embryos of neighboring archegonia were not produced simultaneously, the embryonic selection could not measure the inherent differences in the rate of growth, etc., of the several zygotes. Pollen tubes had not been perfected, so that there probably was a stage in evolution of conifers in which very few forms of developmental selection existed; that is, in which the internal forms of selection in the life cycle were ineffective as forms of selection, or entirely absent. The forms of selection which were operative, if any, were forms of natural selection and clonal selection, which occur in the complex external environment where the effectiveness of selection is much less positive.

In seeking for a possible advantage gained from cleavage polyembryony, one having a survival value, the writer has wondered whether the advent of cleavage polyembryony at this stage might not represent an adjustment which restored a highly effective form of developmental selection to the life cycle. This would assign to cleavage polyembryony a sort of supplementary rôle, one which played an important part in making some kind of embryonic selection possible during the period when male gametophytes became pollen tubes.

Cleavage polyembryony occurs rarely in angiosperms, and no form of polyembryony serves such an important rôle in the higher seed plants, which have long and rapidly growing pollen tubes, and which also possess interovular and other forms of developmental selection. There seems to be little or no evidence in the development of the embryo indicating that angiosperms shared such a polyembryonic history in their embryogeny.

Summary

This discussion shows that cleavage polyembryony is a feature of the embryogeny which must have had its origin before the developmental selection within an ovule had become adjusted, under conditions when only one egg at a time was fertilized. It is possible that this occurred during the stage of transition from independent microgametophytes to pollen tubes, or it may have appeared after this time. In any event, it must have occurred before the present adjustment was perfected wherein pollen tubes take part in the process of developmental selection, and cleavage polyembryony is therefore a palingenetic character. The destructive competition which may be recognized in conifer embryos favors the development of stiff, extremely long suspensors, and also the reversion from cleavage to simple polyembryony. Morphological evidence is presented which supports the explanation that most of the living conifers whose embryogenies are known, perhaps all of them, have passed through a stage of cleavage polyembryony. The latter is therefore a primitive feature so far as conifers are concerned, although some of them have retained cleavage polyembryony as a specialization.

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EXPLANATION OF PLATES V–VII

The following lettering is used in all the figures: *s*, primary suspensor cells; e_1, embryonal tube or tubes of secondary suspensor; e_2, e_3, later embryonal tubes added to secondary suspensor (*s*, e_1, e_2, etc., produced by elongation of cells derived from basal end of embryo); *r*, rosette cells, group of 4 embryo initial cells located above primary suspensors (*s*); rosette cells (*r*) sometimes give rise to rosette embryos (*re*).

PLATE V

FIGS. 1 and 2 are text figures.

FIG. 3.—*Pinus Laricio:* two early embryos on primary suspensors before cleavage of zygotes; ×35.

FIGS. 4–6.—*P. Laricio:* each an embryo complex produced from fertilization of two eggs, with subsequent splitting of two zygotes into four primary embryos each, and development of rosette embryos; fig. 5 is enlarged detail of one of rosette embryos of fig. 4; rosette embryos of fig. 6 enlarged in fig. 25; ×35.

FIG. 7.—*Abies balsamea:* single embryo derived from one zygote (an instance where cleavage polyembryony does not usually occur); ×35.

FIG. 8.—Rosette cells of *A. balsamea* with a 2-celled rosette embryo at *re;* ×105.

FIG. 9.—Rosette cells of *A. balsamea;* ×90.

FIG. 10.—Early embryo system of *Tsuga canadensis*, showing presence of nucleated rosette cells at this stage (before primary embryos have separated); ×105.

FIG. 17.—Detail of rosette cells of *Cedrus libani* during early stage; ×35.

PLATE VI

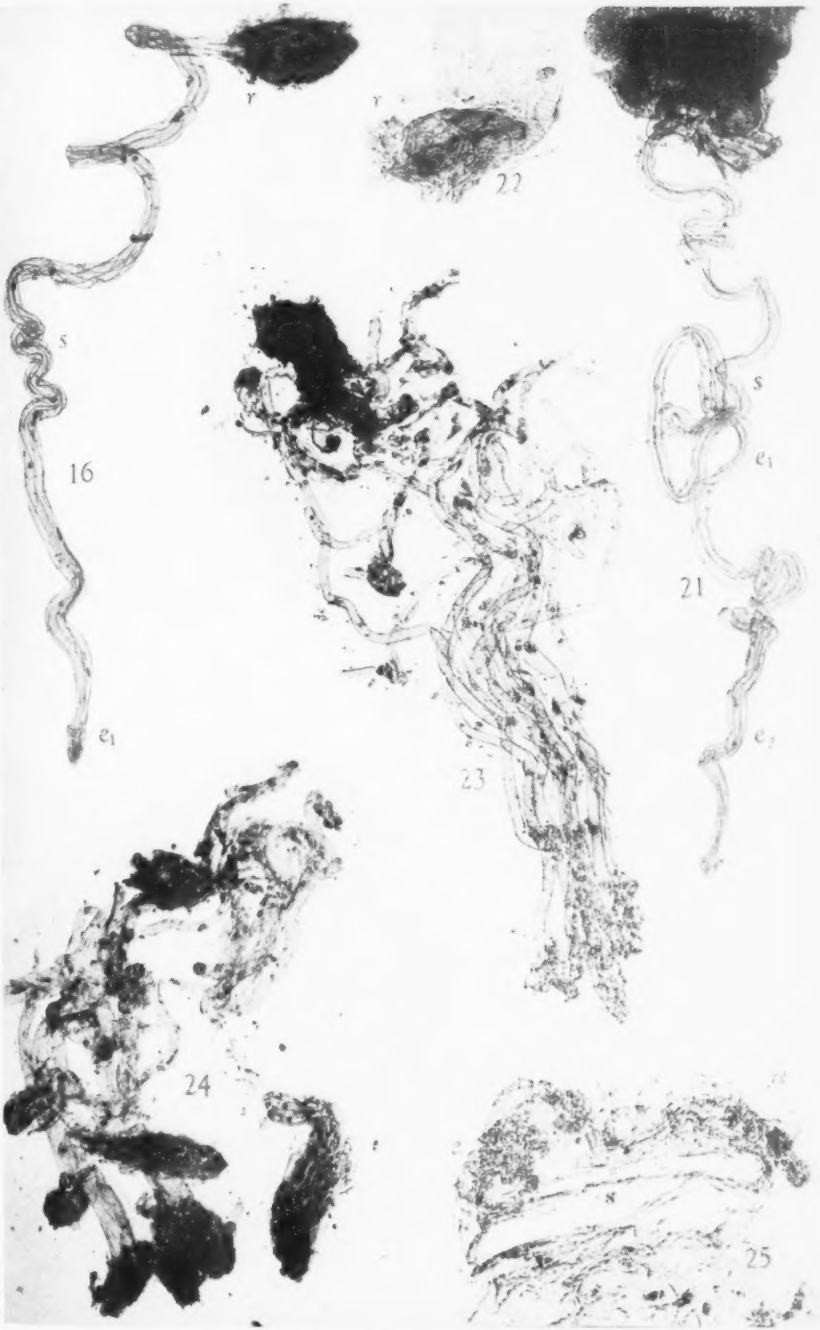
FIGS. 11 and 13.—*Tsuga heterophylla:* fig. 11 shows embryo complex with eleven of the twelve primary embryos derived from fertilization of three eggs; primary suspensors collapsed; each embryo is multicellular and has produced secondary suspensor (e_1 or e_2); ×35. Fig. 13 shows four primary embryos of similar stages under greater magnification; ×72.

FIG. 12.—System of four embryos derived from fertilization of single egg in *Pinus Laricio*, with rosette nearly collapsed at *r;* ×35.

FIGS. 14, 15.—*Pseudotsuga taxifolia:* three of the four archegonia (probably one other archegonium lost in dissection) giving rise to three embryos resulting

BUCHHOLZ on CONIFERS

BUCHHOLZ on CONIFERS



BUCHHOLZ on CONIFERS

from fertilization of three eggs; ×35. Fig. 15, enlarged detail of upper region of suspensor cells, showing absence of rosette cells; ×105.

FIGS. 18–20.—*Cedrus libani:* figs. 18 and 19, rosette regions which have produced rosette embryos; fig. 20, single primary embryo of *C. libani* after cleavage of zygotes (see also fig. 16); ×105.

PLATE VII

FIG. 16.—*Cedrus libani:* young embryo system before cleavage of embryos, showing rosette (*r*); very long primary suspensor (*s*); and beginning of secondary suspensor (e_1); (better view of early rosette may be seen in fig. 17); ×35.

FIG. 21.—Embryo of *Picea excelsa* with primary suspensor and two sections of secondary suspensor elongated; only one embryo produced from each zygote; ×35.

FIG. 22.—Detail of rosette cells of *Picea excelsa;* rosette cells are usually collapsed as shown here; ×105.

FIG. 23.—*Libocedrus decurrens:* embryo complex of many primary embryos produced through cleavage of zygotes; ×35.

FIG. 24.—Slightly older stage than fig. 23; primary embryo at extreme left undergoing further cleavage; ×35.

FIG. 25.—Enlarged detail of rosette region of embryo shown in fig. 6; group of rosette embryos at left slightly out of focus; rosette embryos to right with elongated suspensors unusually well developed rosette embryos; ×72.

THE EL CONSUELO CYCADEOIDS

G. R. WIELAND

(WITH ONE FIGURE)

A general account of the fossil plants of the El Consuelo section of southern Oaxaca, together with detailed stratigraphic measurements, first appeared in 1913.[1] This paper was published as a preliminary to a larger memoir on the plants, later published by the Mexican survey.[2] The first mention of the great wealth of fossil plants of the El Consuelo section and surrounding region, however, was given in a short paper contributed from the Instituto Geologico shortly after the main collections were made in 1909.[3]

Simply characterized, the El Consuelo section cuts a series of mid-Mesozoic freshwater sedimentaries 560 m. thick, perhaps including some Rhaetic, the representative Lias, and the Inferior Oölite, or the Bajocien. On the Rio, or Barranca Consuelo from which the section takes its name, the sedimentaries rest on an eruptive floor and are superposed by marine rocks of mid-Jurassic (Oölitic) age. The section is the type of its kind for the North American continent, and because of the excellent and abundant series of fossil plants it bears, ranks as one of the most important well measured sections of mid-Mesozoic freshwater and marine sediments on the globe. No known region promises the student of upper Rhaetic, Liassic, and doubtless inferior Oölite plants a finer series of forms, or more hope of new discovery than the Mixteca Alta of Oaxaca, Guerrero (near Tlapa), and Puebla. Here especially the members of the Williamsonian tribe flourished in luxuriant abundance. Here grew some of the early angiosperms.

Any facts relating to the plants and the stratigraphy of the El Consuelo section are thus of the utmost interest, and it is of particular importance to record two contributions of the past ten years

[1] The Liassic flora of the Mixteca Alta of Mexico, its composition, age, and source. Amer. Jour. Sci. **36**:251–281. 1913.

[2] La Flora Liasica de la Mixteca Alta. Boletin 31, Soc. Geol. de Mexico. 1916. pp. 160. with atlas of 50 plates (by WERNER & WINTER, Francfurt o/M.).

[3] The Williamsonias of the Mixteca Alta. BOT. GAZ. **48**:427-441. 1909.

affording either new data, new viewpoints, or extensions of earlier views. One of these contributions adds somewhat to the Liassic flora, and is by ENRIQUE DIAZ LOZANO.[4] The other is a critique (with new facts), the title of which is partly explanatory, by BURCKHARDT, so well known for his contributions to the paleontology and geology of Mexico.[5]

I. Cycadeoids of Huayacocotla and Huachinango

It will be convenient to consider first the fossil plants of Lozano. These come from what are apparently two localities in extensions or rather isolated outliers of the Liassic of the El Consuelo section. The first is near the village of Huayacocotla, in the state of Vera Cruz, on the mountain front facing the Gulf at an altitude of 2200 m., in 20°30′ N.L. At the mountain foot the Rio Viñasco, a branch of the Tuxpan, cuts a deep ravine into the frontal escarpment, revealing lower Jurassic and superposed beds. The second plant locality is in Puebla, extending along the Barranca traversed by the Rio Necaxa, where some 4 sq. km. of the plant beds appear to view near the village of Huachinango.

As collected so far, the plants from these two new stations are rather fragmentary, and do not include such fine type specimens as those of the El Consuelo and neighboring sections; but the new localities nevertheless add very interesting forms to the flora already known. As described by LOZANO, the specimens include larger fronds of the *Otozamites Molinianus* Zigno type, a well marked Podozamite of a very fine venation, *Ptilophyllum*, so prominent in the middle strata of the El Consuelo section, two fine specimens of *Pterophyllum*, and a *Cycas* or *Cycadites*. Although mostly single pinnules or but fragmentary portions of fronds, these are really valued additions to the previous series.

A critique of the LOZANO plants is more intelligible if the reader has access to the illustrations, which are clear enough when compared with the plates of the Flora Liasica. The new plants then

[4] Unas Plantas Liasicas de Huayacocotla (Vera Cruz) y algunas Plantas de la Flora Liasica de Huachinango (Puebla). Bol. del Instituto Geológico de Mexico, no. 34. pp. 18. *pls.* 9. 1916.

[5] Quelques Remarques Critiques sur l'ouvrage de M. W. FREUDENBERG "Geologie von Mexico," par Dr. C. BURCKHARDT. Mem. Soc. Cientifica "Antonio Alzate" 41:185–196. 1923.

seem to be an extension of the plants more definitely of Liassic age, as LOZANO concluded. It may be noted that the *Pterophyllum* is perhaps of persistent type. A lesser species of fine venation (1 cm. = 12 v) is close to the *P. propinquum* (cf. SCHENK, Keuper und Lias Frankens), and also easily compared with Liassic species of the Rajmahals (cf. FEISTMANTEL, Jurassic-Liassic Flora of the Rajmahal Group, p. 58). Another *Pterophyllum*, of the Huyacocotla group, represented only by numerous fragments it is true, seems correctly approximated by LOZANO to larger Indian types. It is comparable with the *P. princeps* of OLDHAM and MORRIS; while transition from the fine to the larger and coarse-veined pinnule type is exemplified by the Rajmahal *P. Carterianum*. In passing, one remarks that there were many and striking cosmopolitan elements in the floras of Liassic time, but as in modern types area (extent of distribution) tends to indicate age, so even in the case of these world-wide types of the Liassic, the ever present probability is long persistence in time. The *Ptilophyllum acutifolium* is conspicuously present in the series (cf. LOZANO, Laminas IV–VI, most figures).

In the Lias of Oaxaca no foliage referable to *Pseudocycas* or *Cycas* was found, although one poorly conserved carpellary series was seen and illustrated. Certainly the seeds were present, and the appearance of the matrix suggested the presence of a carpellary crown (cf. pl. 37 of the Flora Liasica). As the Cycadaceae are merely Eastern World relicts, the foliage type has little stratigraphic value, and it is of only casual interest to find in the LOZANO plants a single example. This is, however, quite in error viewed as a species of *Otozamites*, for inspection of the figure (*loc. cit.* pl. 4. fig. 2) suggests elongate insertion of the pinnules, instead of the eared condition doubtfully noted. The appearance is that of slightly overlapping pinnules with a single midrib. LOZANO, in outlining the pinnules of one side of the rachis, seems to have been misled by the presence of a midrib, and so failed to note the inconsistent appearance of his figure. For if this is not a *Cycas* with a single midrib and absence of other venation, there would be some six broader pinnules on the one side of the rachis, corresponding with ten or twelve narrow pinnules on the opposed insertion line. Such an inequality is not possible. Besides, the six broad pinnules show traces of the midrib or vein, and

have the double breadth nearly enough. Again, if the outlining were correct, there would be the curious condition of the displacement of the narrower pinnules in pairs. Until better material is secured, this plant may be regarded as a *Cycadites* of indeterminate species, with fronds under 1 m. in length and 12 cm. or more across, the pinnules being a scant centimeter broad.

Several true species of *Otozamites* are present in the Lozano series, however, as shown on Lamina III, and these are of the greater interest because closely related to the *O. hespera* from stratum 19 in the lower part of the El Consuelo section. One of the forms has a rather broad pinnule, recalling somewhat the *O. Molinianus* Zigno of the Italian Lias. The slight difference between the latter and *O. hespera* is about accounted for by the new pinnule forms. It may then be said that *O. hespera*, taken with two nearly related but distinct species not as yet conveniently named, forms a compact trio of marked Liassic stamp, while the near relationship of this trio of species to certain types of the European Liassic is emphasized.

As showing the difficulties faced by the paleophytologist, the group just cited, with inclusion of the *O. Molinianus*, further relates itself to the *O. obtusus* of LINDLEY and HUTTON from the Liassic of Axminster; and then in turn the general type runs up into the Inferior Oölite *O. graphicus*. In fact, *O. obtusus* has perhaps gained a rather comprehensive status as a species of Liassic-Oölitic range. The form called *O. obtusus* var. *oöliticus* (SEWARD, Jurassic plants, Pt. I, pl. I) does however appear distinct.

An *Otozamites* (LOZANO, Lamina IX) referred to the *O. Hennocquei* is not distinctive, relating itself to both Liassic and Rhaetic types. Similarly another form (LOZANO, Lamina I, fig. 1) is like the Rhaetic *Podozamites distans*.

ANDRIANIA.—Before taking up the notes of BURCKHARDT, it is desirable to make a slight correction of my determination of the oldest plant found in the El Consuelo section. This fossil is from the beds about 35 m. above the base, and thus from well within the strata which could be of Rhaetic if not of Liassic age. It is a portion of a large and fine frond, well outlined, but of indistinct venation, figured as a possible *Laccopteris*.[6] When the description was given,

[6] La Flora Liasica, Lamina XLIV, photograph 3.

however, the features of the *Andriania* of BRAUN, doubtless with *Laccopteris* a member of the Matoninae, had not been noted. Lately a paper by GOTHAN[7] came to hand with an account of forms of *Andriania* of Rhaetic age, which at once recalled the supposed El Consuelo *Laccopteris*, for in *Andriania* there is a very peculiar and characteristic combination of form and venation which, once well noted, would never again be overlooked. Medium sized species have fronds about 8–12 cm. across, with narrow basally confluent pinnules about 6 mm. broad. To this characteristic form of frond is united a peculiar areal, rather than lobate venation, the vein areas being very small, only about 1 mm. broad by 2.5 mm. long. Into each of the succession of these small oblong vein areas, in the species *A. norimbergica*, the strong midrib of the pinnule first sends off a vein to the outer border, with also an anterior short branch vein to the border, and then more basally a longer fork to the border, followed by a single low fork from the midrib. Whenever this simple order of the veins repeats itself, there is each time produced a furrow due to the long vein, and a roll or ridge due to the forked veins, such as is rarely seen in any other fern (fig. 1). In the El Consuelo frond the areal feature is present, although the finer venation cannot be seen. Nevertheless the proportions and all visible features are those of *Andriania*. The first specimen found with clear venation will doubtless prove the point.[8]

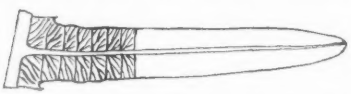


FIG. 1.—*Andriania norimbergica* (Rhaetic of Nürnberg), after GOTHAN.—Vein areas 9 or 10 to the cm. and pinnule width 5 mm., in agreement with *Andriania* (*Laccoperis* ?) sp. of base of El Consuelo section.

Representatives of the Matoninae have not seemed abundant in the Western World so far; but I may add that I noted, in the collections in the Instituto Geologico from the Sonoran Trias, fertile fronds with features so distinct that they could be referred to the Old World species *Laccopteris Münsteri* without question. In speak-

[7] Abh. d. Naturhist. Gesells. Nürnberg. XIX. **14**:pl. 17.

[8] The manner in which *Andriania* relates itself to *Laccopteris* in both fruiting and venation is illustrated by another curious Rhaetic fern from Skone recently described by JOHANSSON under a new generic name *Pterygopteris*. This fern also suggests transition toward *Dictophyllum*. See JOHANNSON, Arkiv för Botanik, K. Svensk Vet-Ak. **17**: no. 16.

ing of those greater trends of change and migration which in later Mesozoic times cut off many of the Matoninae, and which have restricted the sole remaining representatives to a southern rather than to the northern region they once occupied, SEWARD is much impressed by the long persistence of *Gleichenia*, *Dipteris*, and *Matonia*. He states:

> Whatever may have been the main trend of migration, and wherever the ancestral homes may have been, such ferns as *Gleichenia*, *Matonia*, and *Dipteris* are impressive examples of constancy in a changing world; in the course of their wanderings from one part of the earth to another they have suffered but little change since the days which preceded the mysterious rise to ascendency of the flowering plants.

The clearer, the more pointed, and direct it is to add that the representatives of the Matoninae can have, taken alone, but little stratigraphic value after their first known occurrence about Rhaetic time. Even then none may know whether the type was quick or slow to evolve; although once evolved such a type could reach a more or less cosmopolitan distribution almost instantaneously in the lapse of geologic time. Persistence of *Andriania* in the Wealden of France is recorded by CARPENTIER.[9]

The probable occurrence of a typical *Andriania* in the basal strata of the El Consuelo section, however, suggests a certain accord with the observation of BONILLAS, then of the Instituto Geologico, that heavy beds in the valley of the Nochixtlan southerly from Tlaxiaco, carry many Taeniopterids, recalling the Sonoran Trias with its great masses of *Taeniopteris*, and with *Laccopteris*, and many other striking plants.

II. Where does the Lias of the El Consuelo section end?

The El Consuelo section was called the type Liassic section for North America because it was believed to cover Liassic time, with the Rhaetic and Oölite affording the extreme boundaries. Resting on an eruptive floor, the freshwater sediments, nearly 600 m. higher up, run under marine horizons, which in the judgment of BÖSE and

[9] Sur les Conifères et les Fougères du Wealden de Fèron-Glageon (Nord). Ext. Compt. Rendu. Acad. Sci. 1922 (pl. 174).

of BURCKHARDT are middle Oölite. The prominent features of the section follow:

1. Entire thickness of plant beds is nearly ..... 600 m.
2. From eruptive floor to *Andriania*, the oldest plant found in the section ..... 45 m.
3. From *Andriania* to the *Williamsonia Nathorstii* casts ..... 40 m.
4. From eruptive floor to principal coal seam with *Cordaites*, *Noeggerathiopsis*, and *Otozamites Mandelslohi*, etc. ..... 100 m.
5. From main coal to *Otozamites hespera* and *Araucarioxylon* log ..... 140 m.
6. Approximate thickness of lower plant beds ..... 250 m.
7. Main coal to main *Williamsonia* horizon ..... 250 m.
8. From *Williamsonia* with large foliage types to highest point at which distinct plant species were found, about ..... 150 m.
9. From horizon 61 and last of the plants to the marine middle Oölite ..... 85 m.
10. Base to main *Williamsonia* horizon ..... 350 m.

First suggested division:

From eruptive floor to above *Andriania*, Rhaetic ..... 80 m.
Williamsonia Nathorstii to horizon 61, Liassic ..... 400 m.
Horizon 61 to marine beds (mid-Oölite), Bajocien ..... 85 m.

Second suggested division:

From eruptive floor through stratum no. 41, Liassic .... 440 m.
Beginning with horizon 42, where the megaphyllous *Williamsonia* types are first conspicuous and a certain resemblance to the Oölite plants of the Yorkshire coast is first evident, and then extending through horizon 61 to the marine beds, Bajocien ..... 130 m.

Third suggested division:

Lower beds (with most of the coal), Lias ..... 250 m.
Upper beds, beginning above stratum 19, and extending through uppermost strata for 85 m. without distinct plants, Bajocien ..... 320 m.

Of these suggested divisions the first appears the most probable. A certain emphasis must also be laid on the volume of the sediments composing the El Consuelo section in making broader comparisons with the British Jurassic. The ratio of the maximal thickness in these far separated regions must have some relation; in fact, a fairly direct relation to time division. It may be laid down as law that only from all the fossil evidence, and only from the greater sections, or else those very definitely correlated with one another,

can it at some later time be affirmed that any plants of given strata of the Yorkshire coast lived at the same time as certain given plants from the freshwater beds of Oaxaca, or of Puebla, or of Guerrero. The El Consuelo section is probably the most massive lower Jurassic section to be found in Mexico, but the outliers are either unstudied or afford but very partial comparison so far as known. The extent of the beds and the striking outlines of the vegetation they contain make further investigation in field and laboratory extremely urgent. It is convenient to quote from GEIKIE:

> The Jurassic formations stretch across England in a varying band from the mouth of the Tees to the coast of Dorsetshire. They consist of sands, sandstones, and limestones interstratified with softer clays and shales. Hence they give rise to a characteristic type of scenery, the more durable and the more porous beds standing out as long ridges, sometimes even with low cliffs, while the clays underlie the level spaces between.

The contrast between the English Jurassic landscapes and those of the Mixteca Alta is indeed great.[10]

But from the extent of the beds in both of these great type regions, the sequence in which they occur, and the similarity of important floral elements, it is certain that coordinated study and

[10] The ten or twelve thousand feet of Mesozoic strata which give character to the Mixteca Alta are about equally divided between the Jura and Cretaceous, any Trias that may occur not being as yet separated or defined. The Mesozoic mass is often entirely freed from Tertiary eruptives, ash, or conglomerates, and rests on older sedimentaries of undetermined age, or against intrusives. The topography is exceedingly rough. The streams, low in the dry winter and torrential in the rainy midsummer, in cutting through the massive Cretaceous limestones capping Jurassic strata of lesser induration, form a splendid system of flood-cut valleys, gorges, and canyons. Yet because of the more varied vegetation and rather free growth of pine and oak with relatively few barren stretches, scenic aspects are far softer than in the upland mountain country of central Mexico. Subjected as this region has long been to tremendous tectonics, the marine and underlying freshwater deposits form no long crests. And especially the fresh or brackwater sediments 2000 feet thick as deposited along the south continental border for the lower half of Jurassic time, along with thinner marine wedges, are now found where somewhat protected from the full effects of dissection and erosion by border or transverse ranges. Extended areas of the Lias and inferior Oölite are not seen, although in the limited and isolated areas where the rocks of these periods form the surface topography, interesting changes in the vegetation occur. Thus along the Barranca Consuelo the scattering oaks of the eruptive floor contrast sharply with the pines and more varied growth of the Liassic slopes.

Of these isolated Liassic-Oölitic areas extending up to the time when subsidence became pronounced, and all the south continental region was finally invaded by the sea

comparison is but begun. The freshwater divisions of the El Consuelo section correspond in larger outline to the basal development of the British Jurassic rocks. It is therefore of first interest to note the great preponderance of Liassic strata in the British maxima, as follows:

Bajocien =	(*a*) Cheltenham beds or thick estuarines (Inferior Oölite) of Yorkshire up to "Cornbrash" ..... 82 m. (*b*) Northampton sands ("Dogger" of Yorkshire), and (*c*) Midford sands (passage beds) ..... 12 m.	= 94 m.
Lias	Upper Lias ..... 21– 62 m. Middle Lias ..... 18–105 m. Lower Lias ..... 148–292 m.	= 459 m.
Bajocien + Lias, maximum		553 m.

It is thus seen that the El Consuelo section, one of the most accurately and satisfactorily measured in the world so far as the plant beds go, measures almost the same as the British section (570 to 553 m.); while the parallel even extends to the ratio of Liassic to Bajocien sediments, if my first suggested division holds. Had these suggested or trial divisions of the El Consuelo section been made when the Flora Liasica was published, by either the author of that work or anyone else, on the basis of the facts then available, the results reached would have been about the same. Were not the main facts very evident? Was it not emphasized that the great thickness of the section and the many successive phases of sedimentation suggested that one or several unconformities might lie hidden in that great thickness of sediments? Was it not shown that a typical Liassic flora was present, one that looked old enough to extend to the base

about mid-Oölitic time, a number are now known. Of these may be mentioned (1) the Tlaxiaco River valley; (2) three to five kilometers northwesterly from the town of Tlaxiaco; (3) at Mixtepec on the Rio Mixtepec; (4) east of the Cerro del Lucero in the Tezoatlan-Rosario region, a most important unstudied locality; (5) all of the Barranca Consuelo as yet most imperfectly examined for its great store of plants; (6) at the "Pina de Ayuquila" near the village of Ayuquililla in the state of Puebla; (7) near Tlapa in the state of Guerrero, a fruit locality; (8) Huchinango, Puebla; (9) Huayacocotla, Vera Cruz; and (10) the important unstudied region of the valley of the Rio Nochixtlan to the south of Tlaxiaco. The plants yet to be collected in the Mixteca Alta must make those already secured seem small and insignificant in both preservation and number. This region is one of the most favored on the globe for the study of the plant life of the entire Liassic formation, and probably most or all of the Inferior Oölite time.

of the Lias? Was it not seen that some Rhaetic strata might be present? That there was an older phase in the flora? That there were typical *Williamsonia* cones of the largest size among the plants far down toward the base of the section; and that *Williamsonia* became most abundant and varied with ascent in the beds to the point above which, with changes in the character of the sediments, no more plants were found? Was it not seen that the beds of the upper part of the section which did not chance to yield plants were 85 m. in thickness, and might thus easily cover the gap in sedimentation between the close of Liassic time and the superposed marine strata of middle Oölite age; that is, represent the Inferior Oölite, the Bajocien?

It was not for a moment to be inferred that these strata above horizon 61 belonged to the Lias. There was no evidence from the plants, and the question became largely geologic because the flora of the section could be seen to have changed with ascent in the section to near, if not actually into, a true Inferior Oölite plant facies. It was obvious that evidence from other sections, both plant and stratigraphic, ought to be secured before attempting to define the upper limit of the Lias. It was understood earlier, and the fact may be emphasized now, that the transition from the *Williamsonia* elements of the Lias (the chief plants concerned) into those of the Inferior Oölite is not sharp but gradual, and on last analysis undefined. It could easily be that the large leaved *Williamsonia* forms beginning about horizon 42 must finally be referred to the Bajocien.

The point was that the plant collections from the El Consuelo section extended the geographic range of the lower Jurassic floras so notably that it seemed the more satisfactory, even the more philosophic, to let this new body of evidence thus stand out by itself. The outstanding uncertainty was of the upper boundary of the Lias. It was thought, however, that any attempt at a discussion must be more or less premature, especially as more work in the field was then and is still the great need. It is well sometimes to recall the somewhat taunting remark of HUXLEY when it comes to synchronizing far separated sedimentaries and the ancient floras they bear:

> Geologists have imagined that they could tell us what was going on at all parts of the earth's surface during a given epoch; they have talked of this deposit

being contemporaneous with that deposit, until, from our little local histories of the changes at limited spots of the earth's surface, they have constructed a universal history of the globe as full of wonders and portents as any other story of antiquity.

Attention may be called, however, to this early statement of opinion as to the age of the lower Jurassic plants of the Mixteca region (cf. La Flora Liasica de la Mixteca Alta, p. 154, where the words are italicized): "Por lo tanto se deduce que las capas de plantas del corte de El Consuleo están en el límite superior del Rhético y probablemente se extienden al Liásico, cerca del Oölítico inferior." The notes in English read: "It is therefore found that the plant beds of the El Consuelo section begin at the upper borders of the Rhaetic and probably extend through the Liassic near to the lowermost Inferior Oölite." This should refer to the plant beds in the narrower sense of those yielding well defined plant species. Strictly taken the statement could not refer to the basal barren strata; and it emphatically could not refer to the beds above stratum no. 61, now accepted as clearly supra-Liassic.

Of course, in speaking of "plant beds" without reference to age, all the sedimentaries were included as a convenience, from the base of eruptives to the final invasion of the sea in mid-Oölite time, but the fact was repeatedly emphasized that the lower limit of the Lias, and much less the upper limits, could not at once be defined. It was pointed out "that it was not believed that the history of the plant beds consisted in a single unit," and that while no unconformities were found, "several might be present." The opinion was also ventured (and is held still) "that the plants of the Inferior Oölite of the Yorkshire coast are really a left-over Liassic, rather than a typical mid-Jurassic facies." These were mostly the cosmopolitan types that might readily have existed during the deposition of the underlying "Midford sands." These latter contained at their top the famous Gloucestershire "Cephalopoda beds," did not yield fossil plants, were recognized as transition beds, and sometimes actually assigned to the Lias.

From all that has been said about the status of opinion as to the age of the rocks of the El Consuelo section when first measured fifteen years ago, it can be understood how welcome is the finding in

the Oaxacan region of certain marine wedges bearing more or less distinctive Ammonite types tending to throw light on the position of the upper limits of the Liassic. Those interested must turn to the papers of BURCKHARDT for mention of this evidence (1913 and 1923). He states that the freshwater beds of Oaxaca–Puebla must have been deposited along the borders of a Continent (as was earlier granted), since there occur marine interpolations bearing Bajocien *Ammonites*, and the series is in turn overlain by the Bathonian (at Cualac, Guerrero), and by the Callovian in the higher or marine portion of the El Consuelo section. Both formations are rich in *Ammonites*. BURCKHARDT says more recently (1923) of the freshwater series of the El Consuelo section, that my original tentative division into lower and upper plant beds is near a true division into Lias and Inferior Oölite (Bajocien):

> La partie inférieure de la série de couches avec plantes et charbon d'Oaxaca doit être liasique d'accord avec les résultats de Wieland, qui a fait resortir les affinités liasiques de la flore d'Oaxaca tout en méconnaissant l'importance stratigraphique d'autre éléments de la flora qui montrent des rapports intimes avec les plantes oölithiques de la côte du Yorkshire.

That is to say, if I understand BURCKHARDT precisely, he would include in the Lias about the lower 250 m. of the freshwater sedimentaries of the El Consuelo section, or the part containing most of the coal, and in the Inferior Oölite (Bajocien) the upper 320 m.

This division, based upon a much needed further study in the Mixteca Alta region, stratigraphic as well as paleobotanical, may prove to be essentially correct. It is also contended that, taken as a final criticism, such a result would not lie outside the views already outlined at all. The flora offers no obstacle. Above horizon 41 (*cf.* supra) the recovered flora fairly agrees with the Inferior Oölite plants of Yorkshire, certain distinctive species merely appearing a little more megaphyllous, a little more tropical.

There are, nevertheless, in Oaxaca, Puebla, and Guerrero, a number of great sections bearing abundant plants far better conserved than those described by LOZANO from Huachinango and Huayacocotla as already commented upon, which must primarily be brought into exact comparison with the El Consuelo section, before the larger relationships and fuller stratigraphic significance of the

luxuriant and varied cycadeoid floras of the Mixtecan region can be well enough understood. Is it not the outlining of a great field of future study rather than mere technical discussion that is so impressive in this further passage from BURCKHARDT'S critique on FREUDENBURG'S *Geologie von Mexico?*

> Dans le chapitre sur le Lias on trouve une reproduction de la coupe de la Barranca de Huayacocotla de E. BOESE. Les observations que j'ai pu faire en 1913 dans la region de Huayacocotla et Huachinango m'ont demontré que le profil cité de BOESE est inexact. En effet le terrain liasiques, au lieu de se présenter sous forme d'une série de schistes uniformement inclinés avec intercalation d'un grés au milieu, se compose d'une dizaine de zones paléontologiques qui sont très fossilifères et réprésentent une série du Lias inférieur et moyen depuis le niveau de l'*Arietites Bucklandi*, jusqu'à celui du *Polymorphites Jamesoni*. Une zone riche en Bivalves (nombreux *Pecten*, *Trigonia*, et.) contient des roches gréseuses et se présente vers le milieu de la série, au dessus d'un niveau à *Oxynoticeras*. Un peu plus haut s'observent des couches rempliés d'*Echinoceras* du gr. *raricostatum*. Des schistes et grés avec plantes terrestres, dont plusieurs seraient identiques avec des plantes d'Oaxaca, étudiées par WIELAND, et qui ont fait l'objet d'une étude de E. DIAZ LOZANO, sont surmontés par une série transgressive du Jurassique supérieur débutant par un conglomérat de base. Toute cette série est fortement plisée et morcellée par de nombreuses failles.

The fact should be emphasized, therefore, that the several contributions bearing on the age of the plant beds of Oaxaca and Puebla merely form initial and as yet little coordinated studies of this remarkable region. Each successive observer has had to depend primarily on such data as could be assembled during a rapid reconnaissance. That this condition might arise was indeed early noted regretfully by both BÖSE and BURCKHARDT. The responsibility for one failure to continue study and collection in the Mixteca Alta rests on me. AGUILERA, then director of the Instituto Geologico, suggested early in 1910 that it might be better to resume the work in the south, instead of going to Sonora. Had I in the least suspected that fifteen years would pass without further work on the El Consuelo and neighboring sections, I should not then have given precedence to other work in new fields. As events fell, this is the first time that I have been able to give anything like due attention to the data brought to light by others.

It may also be added that it is quite possible that the interesting cycadeoid foliage of the Tlaxiaco River locality (particularly the

fine species *Otozamites paratypus*, Flora Liasica, Lamina XVI, photograph 8), belongs higher in the general sedimentary series than I was at first led to suppose. In that case the large leaved El Consuelo *Williamsonia* forms would stand more isolated as the new species coming in sharply with the advent of Bajocien time; although it was held and emphatically stated that the vegetation of the higher strata of the section appeared juvenile. Such species as *Otozamites paratypus*, *Oaxacensis*, *Aguilariana*, *Diazii*, and *Aguilerii* had led to the idea of newness, or recent and local origin. Indeed these plants, taken as a tropic phase of the greater cycadeoid facies, might well have lived when the Midford sands were laid down. If so, not merely will their evolutionary interest prove marked, but their stratigraphic value will become tangible.

I need not refrain from remarking again that the "stratigraphic significance" of the extinct plants or animals is an intrinsic thing depending on demonstration from available data. It does not rest on surmise, and it seems to me that geologists are apt to expect too much of the plant record, as yet little coordinated, and so often consisting in the indeterminate types of regions remote from each other. Thus the striking *Williamsonia* fruits of the Inferior Oölite, although deeply interesting in discussions of the origin of the angiosperms, are of a more limited, and even local stratigraphic value than is commonly inferred. The cycadeoids cannot have a value like that of *Ammonites* in time determinations. In the case of the dissociated stems, fruits, or leaves of such conservative plant types identification of species is difficult; but in that of the Ammonite shell, which is the full index of a complete organism, identification is easy. It must be admitted that the fine El Consuelo series of *Williamsonia* cones does not disclose more than those broader specific relationships to the cone series of the Yorkshire coast. The features used in specific determination of isolated cones are variable rather than exact. There are no successive series affording certainty of the course of cone persistence and change as yet visible. *Williamsonia Wettsteini* of the Keuper of Lower Austria, the oldest cycadeoid cone thus far discovered, is a large seeded type, which may easily run back to the base of the Trias. The *Cordaites* of the El Consuelo section proved an unexpected persistence of that group; and con-

versely let any one say with caution that any particular cycadeoid species or group of species is young, new, and marks the beginning of Inferior Oölite time.

Conclusions

The several plant-bearing strata of the Lias and Bajocien of Mexico, especially those of the localities and sections herein enumerated, mark one of the most favorable regions of the globe in which to search for antecedent and primitive angiosperms. Accessibility and climate are both very favorable. Conservation of the finest details of leaves and fruits is frequent. Either as imprints or as carbonized forms, many of the types must prove remarkably satisfactory objects for study by the exacter chemical methods. The new angiosperm group Caytoniales, as recently demonstrated from the Inferior Oölite of the Yorkshire coast by THOMAS, is certainly present in the lower strata of the El Consuelo section, where the fine leaf type *Sagenopteris* (?) *mexicana* is barely distinguishable from *Sagenopteris Phillipsi*. That is, this angiospermous foliage positively extends to the base of the Jura in Mexico. Moreover, in the higher or Bajocien strata there is another type of foliage, at first referred tentatively to the Glossopterids, but possibly angiospermous. This occurs as elongate blades inadequately illustrated in the Flora Liasica (Lamina XLVI, photograph 3) as *Glossopteris* (?) *mexicana*. Form and venation are just what might be expected in the Jurassic forerunners of the Lower Cretaceous dicotyls.

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CHANGES IN NITROGEN, POTASSIUM, AND PHOSPHORUS CONTENT OF WHEAT SEEDLINGS DURING GERMINATION AND EARLY STAGES

JEHIEL DAVIDSON

In plant nutrition studies, the absorption of food elements is estimated either by analyzing the residual medium, the difference between it and the original medium giving the quantities absorbed by the plants, or by directly analyzing the plants. The first procedure can be used conveniently only in the case of water cultures. The second procedure is of general application, and would seem to be preferable, being more direct. In analyzing the plants directly, whenever the growth of controls is not feasible, investigators usually compare the quantities of food elements in the seedlings or plants with those in a corresponding number of seeds from the same stock which was used to prepare the seedlings. The fact that changes may occur in the seeds during the process of germination is generally overlooked. These changes may be caused by leaching into the medium or by absorption from ungerminated seed leachings and from tap water. Moreover, seedlings come from vital seeds only, but most stock seed contains some that are sterile, and these may deviate in composition from normal seeds.

This investigation was undertaken to determine experimentally whether seedlings, at the ages at which they are generally transferred to water or sand cultures, differ in composition from the stock seed from which they originate. Should it be shown that under normal conditions appreciable changes take place in the seeds during germination, the composition of plants at the termination of experiments will have to be compared with the composition of the seedlings which were used to start the experiments, instead of with that of the stock seed. The question, besides its bearing on experimental methods, is also of general interest.

Changes in composition of seedlings and ungerminated seeds during germination in tap water

In the Crop Chemistry Laboratory, seedlings are grown from seeds carefully spread out on perforated aluminum disks floating on

tap water, so that the individual seeds will not come in contact with one another. This experiment was conducted in two series: the "sparse," in which wheat seeds were spread out for germination in the usual way; and the "dense," in which the seeds were spread in a continuous layer, each seed being in close contact with the surrounding seeds. A purple straw soft winter wheat of the crop of 1924 was used. At intervals of five and seven days, counting from the time the seed was set to germinate, seedlings, as well as seeds which failed to germinate, were removed and analyzed. All the ungerminated seeds were not necessarily naturally sterile; some seeds, especially in the dense series, probably failed to germinate for some cause other than sterility. A complete set of nitrogen determinations was obtained; phosphorus and potassium determinations were made only on the seeds and seedlings removed from the thickly planted aluminum plate after the seven day period. Aliquots of 30 seeds or seedlings were used for the various determinations, which were made in five replications, except the nitrogen determination in the stock seed, which was made in ten replications. The average results are given in tables I and II.

The nitrogen figures (table I) show that the nitrogen content was appreciably affected by the way the seeds were spread on the aluminum disks. The losses from the ungerminated seeds were not very consistent. Those which were removed after five days lost appreciably in the dense series, but showed no loss in the sparse series. After seven days the ungerminated seeds sustained losses in nitrogen in both series, the losses being appreciably larger in the sparse series. It has been shown elsewhere[1] that no nitrogen in gaseous form is lost during germination. The recorded losses of nitrogen have evidently occurred through leaching. The apparent reversal of conditions with reference to nitrogen losses from ungerminated seeds in the five and seven day sets may be merely accidental, or may be explained by assuming that two factors are involved in the solubility of nitrogenous material in seeds, the state of decomposition of this material, and the solvent action of the medium. Decomposition was probably going on more actively in the dense series, as conditions there were more favorable to microbiological activity than in the sparse series.

[1] DAVIDSON, JEHIEL, Is gaseous nitrogen a product of seedling metabolism? BOT. GAZ. 86:95–101. 1923.

On the other hand, owing to the far greater abundance of ungerminated seeds, the dense series would be more likely to be influenced by the limited solvent action of the medium than the other series. This explanation would seem to be borne out by the fact that the losses from ungerminated seeds in the dense series did not increase after the five day period. While the total loss from the ungerminated seeds after seven days might have been greater in the dense series, the individual losses from seeds were greater in the sparse series.

TABLE I

CHANGES IN NITROGEN CONTENT* IN SEEDLINGS AND UNGERMINATED SEEDS DURING GERMINATION IN TAP WATER

PERIOD	STOCK SEED	UNGERMINATED SEED (MG.)		SEEDLINGS (MG.)	
		Dense	Sparse	Dense	Sparse
.....	20.82	.....	.....	.....	.....
5 days.....	.....	19.78	21.07	21.42	21.07
7 days.....	.....	20.06	19.12	22.76	21.40

* Aliquots of 30 seeds or seedlings.

TABLE II

CHANGES IN POTASSIUM AND PHOSPHORUS CONTENT IN SEEDLINGS AND UNGERMINATED SEEDS DURING SEVEN DAYS' GERMINATION IN TAP WATER*

K_2O† (MG.)			P_2O_5† (MG.)		
STOCK SEED	UNGERMINATED SEEDS	SEEDLINGS	STOCK SEED	UNGERMINATED SEEDS	SEEDLINGS
4.3	.....	.....	9.9	.....	.....
.....	2.8	5.5	.....	8.8	9.4

* Dense series. † Aliquots of 30 seeds or seedlings.

The gains in the nitrogen content of the seedlings are in full accord with this explanation. After five days the seedlings of the dense series showed a gain in nitrogen as compared with the stock seed, and the nitrogen content of the seedlings in the sparse series remained unchanged. After seven days the seedlings in both series showed gains in nitrogen, but the dense series was far ahead, the nitrogen content of the seedlings being about 10 per cent higher than that of the stock seed.

The results in table II show that after seven days the ungerminated seeds sustained appreciable losses of both potassium and phos-

phorus, while the seedlings made a pronounced gain in potassium and showed a slight loss of phosphorus. This is similar in tendency to the results of LeClerc and Breazeale,[2] who grew wheat seedlings on aluminum plates without separating them from the ungerminated seeds during the entire duration of their experiments. Evidently the seedlings were not able to utilize the phosphorus which leached out from the ungerminated seeds, the process of growth protecting them only against excessive losses of phosphorus. The gains of potassium and nitrogen might have come to a small extent from the tap water, which generally contains 1.5–2 parts per million of potassium, and 0.2–1 part per million of nitrogen as nitrate.

Changes in composition of seedlings and ungerminated seeds during germination in distilled water

The experiment was repeated, using distilled water instead of tap water to germinate the seedlings. The plants did not make as good a stand as in the previous experiment, their root systems being especially inferior. The two experiments differ not only with reference to the composition and reaction[3] of the media in which the seedlings were germinated, but also with reference to the vigor of the seedlings. Hence they are not strictly comparable, and only represent a study of the same question under two sets of conditions.

The changes in the potassium and phosphorus content of the seedlings and ungerminated seeds were studied more extensively than in the previous experiment. Determinations were made in both dense and sparse series, and in sets representing three time periods. Owing to shortage of material, aliquots of only fifteen seedlings or ungerminated seeds were used for each determination, and the number of replicate determinations in the five and seven day sets was reduced to two for phosphorus and to three for potassium. For the rest of the determinations five replications were used, as in the previous experiment (average results given in tables III and IV).

The nitrogen losses (table III) from the ungerminated seeds were quantitatively about the same as those in the previous experiment, but they were more uniform and did not vary in the same order.

[2] LeClerc, J. A., and Breazeale, J. F., Translocation of plant food and elaboration of organic plant material in wheat seedlings. U.S. Dept. Agric., Bur. Chem. Bull. 138.

[3] The tap water used generally has a P_H value of 7.4; distilled water a P_H value of about 5.4.

After five days the seedlings showed slight losses of nitrogen in both series. After the seven day period, however, they showed the same gains as in the previous experiment. The seedlings of the dense series again showed an increase of 10 per cent of nitrogen over the stock seed. The deviations from the results of the previous experiment were probably due largely to less vigorous absorption.

TABLE III

CHANGES IN NITROGEN CONTENT* IN SEEDLINGS AND UNGERMINATED SEEDS DURING GERMINATION IN DISTILLED WATER

PERIOD	STOCK SEED	UNGERMINATED SEEDS (MG.)		SEEDLINGS (MG.)	
		Dense	Sparse	Dense	Sparse
.....	10.41	.....	.....	.....	.....
5 days.....	.....	9.97	9.92	10.01	9.75
7 days.....	.....	9.75	10.09	11.42	10.70

* Aliquots of 15 seeds or seedlings.

TABLE IV

CHANGES IN POTASSIUM AND PHOSPHORUS CONTENT IN SEEDLINGS AND UNGERMINATED SEEDS DURING GERMINATION IN DISTILLED WATER

PERIOD	K_2O* (MG.)				P_2O_5 (MG.)				
	STOCK SEED	UNGERMINATED SEEDS		SEEDLINGS		STOCK SEED	UNGERMINATED SEEDS		SEEDLINGS	
		Dense	Sparse	Dense	Sparse		Dense	Sparse	Dense	Sparse
.....	2.15	.....	.....	.....	.....	4.95	.....	.....	.....	.....
5 days....	.....	1.45	1.51	2.23	1.69	.....	4.8	4.8	4.9	4.9
7 days....	.....	0.91	1.47	1.65	2.08	.....	4.2	4.5	4.7	4.6
9 days....	.....	1.03	1.73	1.98	2.39	.....	4.1	4.7	5.0	4.6

* Aliquots of 15 seeds or seedlings.

The same deviation from the results of the previous experiment, probably due to the same cause, is shown by the potassium content (table IV) of the seedlings. Although the ungerminated seeds of the seven and nine day sets in the dense series showed greater potassium losses than in the previous experiment, the seedlings of the same sets and the same series not only made no gains in potassium, but even showed losses which were appreciable in the seven day set. Evidently the conditions of these experiments were more favorable for the leaching of potassium from the ungerminated seeds as well as from the normal mother seeds, than for its absorption by the seedlings. The results in changes in the phosphorus content are in full

accord with those obtained previously, showing losses from ungerminated seeds in the seven and nine day sets, and only a slightly changed phosphorus content in the corresponding seedlings.

Appreciable losses of phosphorus occurred in the ungerminated seeds of the dense series in the seven and nine day sets; in all other cases the changes in the phosphorus content are but slight (table IV). There is more variation in the potassium content. The potassium figures indicate a race between the leaching of this element from the seeds and its absorption by the seedlings. The losses of potassium from the ungerminated seeds are greater in the seven and nine day sets of the dense series than in the corresponding sets of the sparse series. This is probably true also of the mother seeds attached to the growing seedlings. After five days, when conditions favoring the leaching of potassium had not developed fully, the seedlings of the dense series showed a slight increase in potassium over the stock seeds; the corresponding seedlings of the other series showed a loss. This was probably due to the difference in stand of the plants, which was somewhat more vigorous in the dense than in the sparse series. As the losses through leaching from the mother seeds in the subsequent periods increased in the dense series, while remaining stationary in the sparse series, the seedlings of the sparse series began to gain in potassium over the corresponding seedlings in the dense series, and at the nine day period showed a pronounced increase over the stock seeds, while the seedlings of the dense series showed a potassium content below that of the stock seed. Evidently absorption of potassium by the seedlings of the dense series did not keep up the race with leaching of the same element from the mother seeds.

Discussion

The results of the two experiments show that wheat seedlings, within the age limits in which they are used for experimental purposes, while changing but slightly in phosphorus content during germination, vary appreciably in nitrogen and potassium content from the stock seed from which they were obtained, depending upon their age and the conditions under which they were grown. Seven days from the time the seeds were set to germinate, when the tops were about 3 inches high, both experiments showed an increase of about 10 per cent of nitrogen over the stock seeds when they were

germinated in a dense continuous mass of one layer. LIPMAN and TAYLOR[4] report direct fixation of atmospheric nitrogen by wheat plants, grown without added nitrogen, basing their conclusions on gains over the stock seed fluctuating between 20 and 50 per cent of the original nitrogen content. An increase in the content of the seedlings during germination of the same magnitude as obtained in these experiments would have cut down the reported gains. The main thesis of this paper would seem to be well founded, therefore, the results indicating that in plant nutrition studies the seedlings with which the experiments are studied are a safer standard of comparison than the stock seed from which they were grown.

The losses of nitrogen, potassium, and phosphorus observed at certain phases of the experiments were probably due largely to leaching, and partly perhaps to absorption by microorganisms. Potassium could not have been lost in any other way; no nitrogen (see footnote 1) in gaseous form is lost during germination and early life of wheat seedlings; and volatile phosphorus compounds are very limited in number, and probably would not develop under the conditions of these experiments.

The reported gains of potassium come principally from leaching from ungerminated seeds, and in part perhaps from the potassium content of the tap water in the first experiment. The reported gains in nitrogen also come mostly from ungerminated seed leachings. Possible direct fixation of nitrogen, as reported by LIPMAN and TAYLOR, could hardly account for such relatively large gains in a short time. Furthermore, the possibility of direct fixation could not very well be harmonized with the pronounced difference in nitrogen gains between the seedlings of the dense and those of the sparse series. There is no apparent reason for such a difference in fixing power between the two sets of seedlings, both of which were normal. The possibility of nitrogen fixation by microorganisms, however, is not excluded, as the wheat leachings formed a very good medium, especially in the dense series, for microorganic growth.

The results reported here have a bearing also on the possible deficiency of sterile seeds in plant food elements. The nitrogen, potassium, and phosphorus contents of the seeds which failed to

[4] LIPMAN, C. B., and TAYLOR, J. K., Do green plants have the power of fixing elementary nitrogen from the atmosphere? Jour. Franklin Inst. **198**:475–506. 1924.

germinate were generally lower than those of the stock seed, especially in the case of potassium. Is it possible that besides the losses by leaching which are inferred from corresponding gains, sterile seeds are naturally deficient in these elements? The results of these experiments seem to lend no support to the possibility. Losses of phosphorus from the ungerminated seeds were very slight in the earliest period but increased subsequently. The consistent differences in the potassium content of the ungerminated seeds between the dense and sparse series would also tend to show that the losses were largely due to leaching. The possibility that sterile seeds are deficient in some plant food elements is not excluded, but more experimentation would be necessary to prove or disprove this.

Summary

1. Wheat seedlings, between the age limits in which they are generally used for experimental purposes, differed in composition from the stock seed from which they were obtained. They either lost or gained potassium and nitrogen, depending upon their age and the conditions under which they were grown, but changed little in phosphorus content.

2. Seven days from the time the seeds were set to germinate, or three to four days after germination, the nitrogen content of the wheat seedlings was about 10 per cent greater than the nitrogen content of the stock seed, when it was spread to germinate in a dense continuous layer.

3. The results indicate that the gains in nitrogen and potassium were due chiefly to the absorption of materials leached from the ungerminated seeds.

4. The ungerminated seeds consistently lost more potassium, nitrogen, and phosphorus than did the seedlings. The results, however, do not settle the question as to whether sterile seeds may be naturally deficient in these elements.

5. It is recommended that in plant nutrition studies the seedlings with which the experiments are started, rather than the stock seed from which they were grown, be used as a standard of comparison.

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EVAPORATION IN THE SCIRPUS VALIDUS AND S. AMERICANUS ASSOCIATIONS[1]

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(WITH PLATE VIII AND ONE FIGURE)

Introduction

In connection with some work endeavoring to discover the reason for the succession of *Scirpus validus* by *S. americanus*, the replacement of an association of relatively high plants by one of lower plants, atmometers were used in the vicinity at different levels in different years. The present paper is a report of the evaporation conditions found at the tension line between the two associations, and at the levels of the tops of the culms of the two species of *Scirpus*. Following some preliminary work, carefully planned series were used in the summers of 1921 and 1922. The writer is indebted to Miss ALICE E. KEENER for nearly all of the reading of the instruments during the first year; and, during the summer of 1922, when a more extensive series was used, to Mrs. RUTH H. WEST for the same assistance. The work was carried on at the University of Michigan Biological Station at Douglas Lake, Cheboygan County, Michigan.

Methods

Standardized Livingston spherical atmometers were used throughout the course of the work, one of each pair a white sphere and the other a blackened sphere. During 1921 the mercury glass wool valves of Livingston-Thone[2] were employed, while during 1922 the Gates' modification of the Musch rain correcting valve was utilized. In all cases the atmometer was set in an ordinary jar through rubber stoppers, in which there was also a tube projecting above the rubber stopper. The instruments were filled to the mark on this tube, which when in ordinary use was covered with a loose fitting cap. Burettes reading to 0.05 cc. were employed. In setting

[1] Contribution no. 245 from the Botanical Laboratory of the Kansas State Agricultural College.

[2] THONE FRANK, Rainproofing valves for atmometers: A résumé. Ecology 5:408–414. 1924.

up the instruments, stakes were driven into the ground, cross pieces arranged at proper heights, and the bottles wired on so that the atmometer cups were exposed at the desired elevation. Where two levels were maintained, a separate stake was utilized for the lower one, and was located a very short distance south of it, so that there was no possibility of shade from any part of the apparatus falling upon any of the cups. These were read at moderately regular intervals and the data recorded.

Description of stations

During 1921 two sets were used in Deer Bay, in the first of the crescent-shaped beach pools (Pl. VIII). These beach pools were separated from Douglas Lake by a narrow sand bar, which in years of high water might be covered. The vegetation of most of the beach pools was a very dense growth of *Scirpus americanus*, in a few parts of which, especially toward the western corner, moderate sized patches of *S. validus* were present. At the edges of the pools, and up to the ridges separating them there might be examples of *Salix-Cornus* thickets, and scattered throughout, where it was possible for them to grow, were a few secondary species, all much shorter than either *Scirpus*, and consequently of no effect upon evaporation from the atmometers.

One set was used in the western part of the largest of these beach pools and a second in the central part. In the first case the set was located at the tension line between rather large patches of *S. validus* and *S. americanus*, while the other was located at the edge of a moderate sized patch of *S. validus* in an extensive area of *S. americanus*.

During 1922 several sets were used, one of which was in Deer Bay, located on the same stakes as were employed in 1921. Another set was used in a cove west of Grapevine Point, where *S. americanus* forms rather extensive growths running from the very shallow water back to the land, and in some cases quite back to the fringing ridge, which is either shrub or tree covered. *S. validus* is now rather scarce here, having suffered severely a few years ago from ice work. The atmometers were set up in the same manner, on the tension line between small patches of *S. validus* and the edge of a rather large

patch of *S. americanus*. At the time the apparatus was set up in June, the water of the lake was about 15 cm. deep, but the lake level lowered during the course of the summer, so that the stakes were on land at its close. In this location there was marked protection from southerly winds, as the bluffs behind rose to heights of 6–8 m. Further, there was a moderate amount of protection from northerly winds, on account of the shelving beach which projects out some hundred or more meters and breaks the effect of storm waves.

At the west end of the lake two sets were used, one in the cove west of Maple Point, and the other in the open lake to the east of Maple Point. In the case of the cove, the atmometers were placed at the edge of a sparse growth of *S. validus* where it approached the *Eleocharis* consocies of the *S. americanus* association. In this situation there was a certain amount of protection from most of the northerly winds, and the location of the cove is such that wave action was very slight.

The set placed east of Maple Point was located at the base of Phragmites Flat, in a medium dense growth of *S. americanus* at the edge of a moderate sized patch of *S. validus*. In this situation protection was afforded from west winds and less so from north winds, but from all other directions there was nearly a full sweep of the lake.

During 1920 and 1921, atmometers were placed in *S. validus* on the Big Shoal, which projects somewhat more than a kilometer out into the lake. The station was fully exposed to winds from all directions, and was well calculated to show the extreme of evaporation conditions which *S. validus* withstands. Here *S. validus* was present without associated species of higher plants. It was growing in water 1.4–1.8 m. in depth, and projected above this about 1.2–1.5 m. Water of such depth makes it entirely impossible for *S. americanus* to develop.

During July and most of August, 1920, the evaporation from a white atmometer here averaged 34.54 cc. per day. In the season of 1921, a white atmometer averaged 42.88 cc. per day from July 2 through August 16. Up to August 8 a black atmometer averaged 55.73 cc. per day, while a white one averaged 45.4 cc. per day for the same period. These data indicate that *S. validus* can withstand high evaporating conditions of the air.

The standard atmometer is that located at the Biological Station to permit comparison between different seasons.

Results and interpretations

Comparing the actual rates of evaporation, it is obvious that evaporation varies from year to year and from station to station over a rather wide range. As the averages are moderate to high, it is evident that *Scirpus* is well able to withstand high evaporating conditions of the air. Its roots are submerged, so that apparently there is a superabundance of water to supply transpiration. As was to be expected, the black atmometers uniformly showed a higher rate of evaporation than the white at the same levels. This was most pronounced of course in dry sunny weather, usually between half again and as much again as evaporated by the white atmometers.

Variation between the seasons was accompanied by similar variation in rates; for instance, the white standard rates in 1921 and 1922 were 29.44 and 22.59 cc. per day respectively, while the atmometers in Deer Bay which were run in both these years gave 19.70 and 15.28 cc. per day for the same times. In a season of less evaporation. the ratio of the black to the white atmometer was less (1.69 in 1921 against 1.25 in the cooler 1922).

The atmometer at the higher level (that of *S. validus*) always evaporated more than the corresponding one of the pair at the lower level (that of *S. americanus*). The difference of 0.6 m. from about 0.4 to about 1.0 m. made a difference of from 1.16 to 1.37, compared with unity at the lower level, for different situations in the cases of the white atmometers, and from 1.07 to 1.40 similarly with the black atmometers. A black atmometer at the lower level usually showed a higher rate of evaporation than a white atmometer at a higher level, indicating that within the difference of elevation concerned (about 0.6 m.) the insolation was of greater importance than any other factor.

Comparing the black to white ratios at different levels, it was noted that the ratio, with a single exception, was higher at the lower level. This was probably because the extra energy of insolation could make itself felt strongly, while, in the presence of a decreased circu-

lation at the lower level, the rate from the white atmometer was diminished. The greatest difference was at Deer Bay in 1922, when the black to white ratio at the higher level was 1.25, while at the lower level it was 1.57.

At the level of the culms of *S. validus*, there was no significant change of ratio with the standard during the course of the season. The variations above and below the averages are easily accounted for by the variabilities of the weather conditions, especially the amount and direction of the wind and the moisture in the air.

Comparisons of the results obtained at the level of the culms of *S. americanus*, however, showed a tendency to be lower later in the season. This would be expected, because of the increase in density of the vegetation during the season; but the fact that it was so small, and in the more exposed habitats so uncertain, simply means that the increase in height and number of the slender flexible upright *Scirpus* culms is but slightly effective in decreasing the air currents and shade, thus reducing the evaporation below that "normal" for a station at the 0.4 m. level. Further, the normal habitat of both species of *Scirpus* is quite an exposed one, especially so in the case of *S. validus*.

While the ratios of either the white top or the white bottom to the standard were usually rather closely similar, although of different amounts, the introduction of rainy days, or especially a rainy period, would throw these ratios greatly to one side in the cases of the black atmometers as compared with the white ones.

In the stations employed during the course of the atmometer work, it did not appear that the plants of either species of *Scirpus* were growing under air conditions that were in the slightest affecting them because of injurious lack of water. The action of other factors was often quite obvious. With respect to diminished evaporation, both *S. americanus* and *S. validus* grew in competition with *Salix-Cornus* thickets, if these thickets approached over wet ground. Actual shade eliminated *S. americanus* quickly, but *S. validus* persisted in several cases into thickets of moderate density, and even into a light forest in rare cases. In such places the evaporation is always conspicuously lower than in the open. In all cases, however, the roots of these species of *Scirpus* were at or below the water table

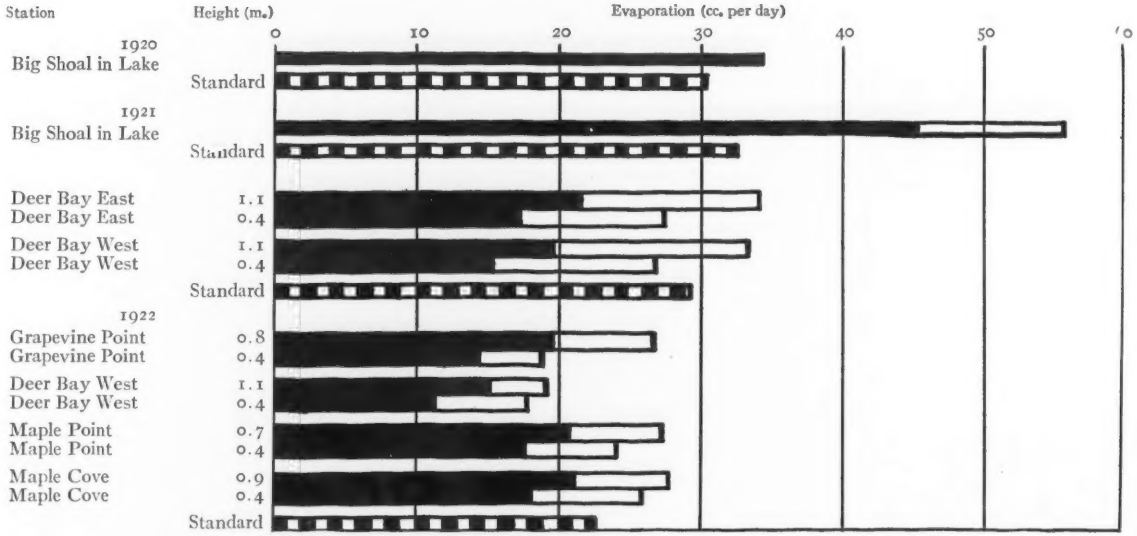

FIG. 1.—Diagram of average daily evaporation from atmometers in *Scirpus* association (upper at level of *S. validus*, lower at level of *S. americanus*), and from the standard at Biological Station for same periods; solid portion of line indicates white atmometer, black edged projection indicates additional evaporation from black atmometers of the pairs, and broken line indicates standard (white) for of time associated group.

TABLE I

AVERAGE AND EXTREME VALUES OF EVAPORATION AROUND S. VALIDUS AND S. AMERICANUS AND RATE OF STANDARD AT BIOLOGICAL STATION DURING SAME TIME

YEAR	STATION	DAYS OF RECORD	TOP*				BOTTOM*				STANDARD DURING SAME PERIOD
			BLACK		WHITE		BLACK		WHITE		
			Average†	Extreme†	Average	Extreme	Average	Extreme	Average	Extreme	
1920	Scirpus in lake	46	.....	.....	.....	.....	.....	.....	34.54	$66.89^{1\cdot0}$	30.44
1921	Scirpus in lake	38	.....	.....	.....	.....	55.73	$72.72^{2\cdot5}$	45.40	$55.58^{3\cdot5}$	32.68
1921	Deer Bay east	52	34.24	$52.93^{2\cdot5}$	21.62	$33.62^{2\cdot5}$	27.63	$44.96^{2\cdot5}$	17.23	$26.69^{2\cdot5}$	29.44
1921	Deer Bay west	52	33.30	$57.08^{3\cdot5}$	19.70	$34.69^{1\cdot9}$	26.88	$46.33^{1\cdot9}$	15.54	$27.11^{1\cdot9}$	29.44
1922	Grapevine Point	50	26.76	$48.02^{2\cdot9}$	19.72	$36.20^{2\cdot9}$	19.11	$29.16^{4\cdot5}$	14.39	$23.94^{2\cdot9}$	22.59
1922	Deer Bay west	50	19.14	$33.14^{2\cdot9}$	15.28	$28.21^{2\cdot9}$	17.95	$30.61^{2\cdot9}$	11.40	$23.82^{2\cdot9}$	22.59
1922	Maple Point	49	27.39	52.80^{2}	20.82	43.83^{2}	24.14	44.50^{2}	17.84	36.49^{2}	22.59
1922	Maple Cove	49	27.75	78.10^{2}	21.19	63.49^{2}	25.93	72.80^{2}	18.20	58.20^{2}	22.59

* Top designates level of *S. validus* culms (varying 0.7–1.1 m.); bottom designates level of *S. americanus* culms (varying 0.35–0.45 m. above water).

† The average during the summer is expressed in cc. per day, with the Extreme columns expressing the extreme rate during a period, the duration of which in days is expressed by the exponential figure to the right.

level. So long as this was true, it appeared to make no difference whatever with respect to the evaporating condition of the air in itself.

Summary

The evaporation results herein reported were obtained in connection with some studies on the *S. validus* and *S. americanus* associations, in the vicinity of the University of Michigan Biological Station on Douglas Lake, Cheboygan County, Michigan, during 1920, 1921, and 1922.

From the fact that *S. validus*, provided its roots are at or below the water table level, will grow under a wide range of evaporating conditions, including exposure to those both less and more severe than under normal successional conditions, it is evident that evaporation has nothing to do with the succession from the *S. validus* to the *S. americanus* association.

The actual averages and upper extremes at the height of the *S. americanus* culms and at the height of those of *S. validus* are shown in table I and fig. 1. Within the limitations of this experiment at least, the blackened condition of the atmometer was more potent in increasing the rate of evaporation than elevating the instrument.

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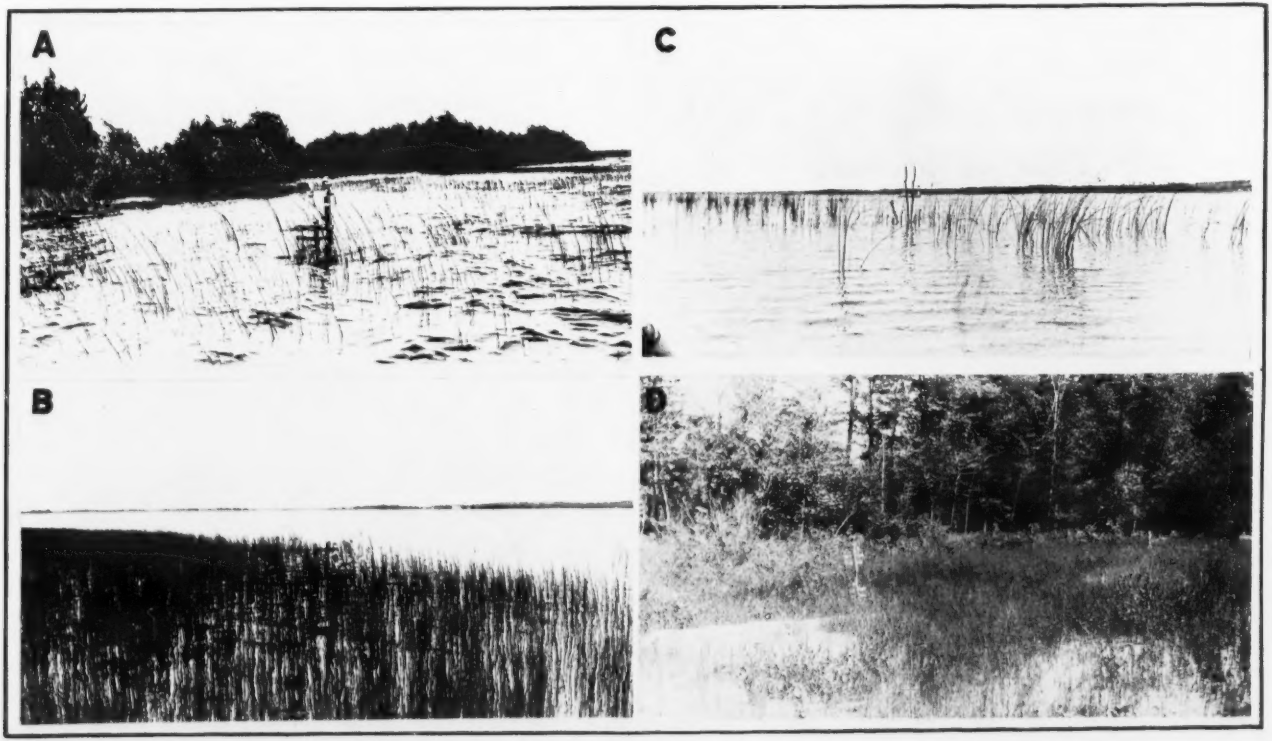
EXPLANATION OF PLATE VIII

PLATE VIII

Atmometer set-ups in *Scirpus* vegetation in Douglas Lake, Michigan, except for *C*, on tension lines between *S. validus* and *S. americanus* associations: *A*, view to east of Maple Point, showing *Scirpus* zone near beginning of growing season (June 25, 1922); *B*, same as *A*, but taken from shore after season's growth had been completed (August 11, 1922); *C*, view on Big Shoal, showing open development of *S. validus* association in water over 1.6 m. deep (August 3, 1921); *D*, view in Deer Bay, showing dense development of *Scirpus* associations (July 1, 1921).



GATES on SCIRPUS

INHERITANCE OF PUBESCENCE IN PHARBITIS NIL

YOSHITAKA IMAI

The stem of the common strains of *Pharbitis Nil* (the Japanese morning glory) is more or less silver gray in color in reflected light, on account of the somewhat dense hairs growing downward on its surface. In one of my pedigrees, no. 65, the development of the hairs on the stem is very poor, however, and the stem which grows out in the autumn is almost free of hairs. Because of this condition the stem and the foliage of the strain are of vivid color. Roughly speaking, the strain may be said to have a smooth stem.

Crossing this strain with the hairy normals, I obtained F_1 plants having a hairy stem, and they gave rise to the F_2 offspring composed of the hairy and the smooth stems in nearly the usual ratio. With these results, we may assume that the smooth stems which are produced breed true to type in the subsequent generation. Some of the F_3 families of these smooth stems, however, gave unexpected results, segregating into smooth and hairy stems. Thus the hairy condition behaves either as a dominant or a recessive to the smoothness in the descendants of the same cross.

The smooth condition is commonly found to be recessive to the hairy state in many different species of plants. According to Miss SAUNDERS (2), and MIYAKE and IMAI (1), however, the hair of the stem in the foxglove is transmitted as a recessive allelomorph to the so-called smoothness. The smooth stem in this plant is not entirely or nearly free from hairs, only the upper flowering part of the stem being almost smooth. In *Pharbites Nil* the relative development of hairs on the stem is represented in a manner somewhat similar to that of *Digitalis*, but the genetic behavior is more complicated, on account of the occurrence of a dominant hairy stem.

Experimental results

The F_1 plants obtained by crossing a smooth stemmed strain (65) and two hairy stemmed specimens (326 and 220) had quite

hairy stems; their reciprocal matings gave no different results. Table I gives the results obtained in raising the F_2 offspring.

TABLE I

CROSS	HAIRY STEM	SMOOTH STEM	TOTAL
65×326.....	93	30	123
65×220.....	141	25	166
Total.....	234	55	289
Expected (13.3)	234.81	54.19	289

TABLE II

F_3 DATA OF CROSS 65×326

CHARACTER OF F_2	PEDIGREE NUMBER	HAIRY STEM	SMOOTH STEM	TOTAL
Hairy stem	Total of 38 pedigrees	1153		1153
	33	19	6	25
	36	19	7	26
	41	?	?	(101)
	42	11	3	14
	43	12	3	15
	46	11	7	18
	47	23	8	31
	49	38	6	44
	54	7	4	11
	57	42	14	56
	61	18	9	27
	62	29	14	43
	66	43	11	54
	67	18	6	24
	69	4	1	5
	71	6	4	10
	Total	300	103	403
Smooth stem	Total of 8 pedigrees		236	236
	28	13	29	42
	29	5	10	15
	30	2	8	10
	31	22	62	84
	34	7	19	26
	37	1	6	7
	39	1	3	4
	40	4	12	16
	63	4	11	15
	70	5	14	19
	73	4	8	12
	Total	68	182	250
	Expected	62.5	187.5	250

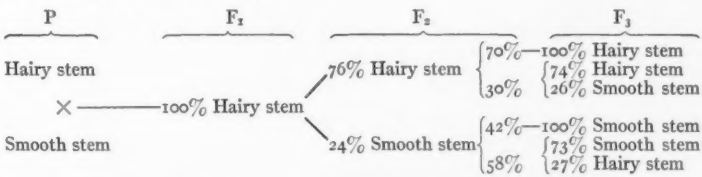
The segregating number is not very far from the simplest ratio of 3:1, and we might think that the case is one of monohybrid inheritance, but the case is not so simple when the F_3 data are examined. The actual segregation may be a modified dihybrid ratio of 13:3, the former having hairy stems and the latter smooth ones. The F_3 results obtained from a cross, 65×326, are shown in table II.

OFFSPRING OF HAIRY STEMMED F_2.—Roughly speaking, the results of the hairy stemmed F_2 are divided into two classes, the one breeding true and the other segregating into hairy and smooth stems. The segregating number in total nearly corresponds with that calculated on the basis of 3:1. Theoretically, however, the average proportion must be $3>1$, as will be shown in the next section.

OFFSPRING OF SMOOTH STEMMED F_2.—The F_3 families of the smooth stemmed F_2 are equally divided into two types, those breeding pure and those producing hairy stems. Now we have a case of reversal segregation, namely, the segregating smooth stems produce the hairy stems. The segregating hairy stems are in the proportion of 27 per cent of the total number, consequently the case may be considered as practically 3:1 segregation.

Discussion

In summing up, the results obtained by the cross 65×326 may be shown graphically as follows:



The dominant nature of the hairy condition can be learned by the fact that the F_1 plants all had hairy stems, and they produced smooth stems in about one-fourth of the total F_2. Some smooth stemmed F_2 plants, however, produced offspring consisting of the smooth and the hairy stems in the proportion of 3:1. The result shows entirely reverse behavior in the segregation of the similar characters.

Now let us assume two allelomorphic pairs of factors in relation to the development of the hair on the stem: (1) H_s, h_s.–H_s inhibits

the production of hairs on the stem, while its recessive factor h_s is responsible for the hairy stem; (2) H_h, h_h.–H_h acts as an inhibitor to H_s, making the stem hairy.

Then the genetic composition of the parental hairy stems should be $h_sh_sH_hH_h$, while the smooth partner is considered to be $H_sH_sh_hh_h$. In the consideration of the former composition two alternatives may be offered, $H_sH_sH_hH_h$ or $h_sh_sh_hh_h$, but neither of them can be thought of as the actual case, since the F_1 plants must have a double heterozygotic constitution. The free combinations of the factors in the F_2 generation should give:

Reference	Genetic composition	Its ratio	Character	Its ratio
A	$H_sH_sH_hH_h$	1	Hairy stem	13
	$H_sh_sH_hH_h$	2		
	$h_sh_sH_hH_h$	1		
	$h_sh_sH_hh_h$	2		
	$h_sh_sh_hh_h$	1		
B	$H_sH_sH_hh_h$	2		
	$H_sh_sH_hh_h$	4		
C	$H_sH_sh_hh_h$	1	Smooth stem	3
D	$H_sh_sh_hh_h$	2		

The ratio of the hairy and the smooth stems is 13:3. With such an expected ratio as a basis, the observed and the theoretical numbers approximately corresponded, as was shown in the bottom line of the F_2 table. Out of seven hairy F_2 genotypes, five grouped in *A* should phenotypically breed true to the hairy stem, whatever their constitution may be. The remaining two types grouped in *B*, however, should produce segregating families; the one, single heterozygotic type, will produce hairy and smooth stems in the ratio of 3:1; while the other, double heterozygotic type, may give the two forms in the proportion of 13:3. The two types of ratio, 3:1 and 13:3, are not so different that they can always be distinguished easily one from the other with the numbers which were observed. Those families which produced some smooth stems are then considered to be composed of two types of segregation; so the ratio in the total number should be $3>1$, but not 3:1. The actual ratio, however, was nearly 3:1, not $3>1$. This unexpected result may be partly accounted for at least by the difficulty of distinguishing between the two forms. Although in the majority of the cases the

classification was not hard, it was sometimes difficult. The extreme case is exhibited in family 41, of which I failed to take reliable records as to the segregating characters. Such difficult conditions for identification seem to admit of some qualifications in judging the data. Out of two smooth stemmed F_2 genotypes one (*C*) should phenotypically breed true to the smooth stem, while the other (*D*) will produce smooth and hairy stems in the ratio of 3:1. These expectations coincided nearly with the actual data.

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1. MIYAKE, K., and IMAI, Y., On the inheritance of flower-color and other characters in *Digitalis purpurea*. Jour. Coll. Agric. Imp. Univ. Tokyo 6:391–402. 1920.
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BRIEFER ARTICLES

GERMINATION OF SEEDS OF PLANTS NATIVE TO DUTCHESS COUNTY, NEW YORK[1]

Appreciation of the value of the propagation of native plants is growing rapidly among those interested in landscape gardening and in plant conservation. The attractiveness of some of these plants makes an increased supply of them desirable, while some of the more striking will soon become extinct if no effort is made to check the destruction of the natural supply.

The department of botany at Vassar College, in cooperation with the Conservation Committee of the Garden Club of America, is working upon this problem, from the standpoint of obtaining information in regard to the germination of seeds of native plants. The growth of native plants from seed insures the widest utilization of such plants and the least loss. Seeds of some introduced plants have been included in this study.

Treatment of seeds

The collections were made in September, October, and November of the years 1922, 1923, and 1924. Dry fruits were shaken or pounded to loosen the seeds, which were then sifted out, and stored in paper sacks in a dry place at room temperature (20°–25° C.) until needed. Pulpy fruits were dried and stored in the same way. When the seeds were to be used, the fruits were soaked in water, mashed, and the pulp washed away. Sterile water only was used to rinse the seeds. In the experiment where nipping was used, the seed coats were broken through to the endosperm by means of scissors before the seeds were sterilized. Petri dishes were fitted with pieces of filter paper and cotton, and then sterilized in an oven for two hours at 160° C. The sterilized seeds were spread on the filter paper which had been moistened with sterile water.

In the experiments made from October, 1923 to May, 1924, twenty-five seeds were used in each dish. In tests made from October, 1924 to March, 1925, one hundred seeds were used in each dish. Two dishes were used in each experiment, both being kept at 20°–25° C., but one in diffuse

[1] This investigation was conducted under the direction of Dr. EDITH A. ROBERTS, whose aid and encouragement are gratefully recognized by the writer.

light and the other in the dark. The paper was moistened with sterile water every two or four days as needed.

The experiments set up from October, 1923 to March, 1924 were observed from the date of setting up until June 1, 1924. Those set up during April and May, 1924, were observed until June 10, 1924. Those set up from October, 1924 to March, 1925 were observed until the latter part of April, 1925. Records of germination were made from two to eight days apart.[2]

Results

TABLE I

SEEDS UPON WHOSE GERMINATION LIGHT HAS A BENEFICIAL EFFECT

NAME	YEAR COLLECTED	LIGHT		DARK	
		Days	Percentage germination	Days	Percentage germination
Anaphalis margaritacea	1922	4–9	18	5	12
	1924	4–12	50	4–12	12
Apocynum cannabinum	1923	6	44	6	4
	1924	5	13	6	12
Anemone virginiana	1924	29–75	66	181	0
Cuscuta arvensis	1923	5–133	39	4–90	18
Daucus Carota	1922	17	44	27	0
	1924	91	1	151	0
Dianthus Armeria	1922	9–16	88	4	8
	1923	4–33	79	4–82	31
Echium vulgare	1924	2–7	91	158	0
Eupatorium purpureum	1922	12	20	26	0
Gentiana Andrewsii	1923	95–209	0	95–219	0
	1924	14–30	80	20–50	18
Helenium autumnale	1923	12–61	19	21–243	0
Hesperis matronalis	1923	3–51	80	5–12	28
Heuchera americana	1923	15–38	47	14–47	12
Linaria vulgaris	1922	11–17	24	31	0
	1923	9–59	15	20	1
	1924	13–26	21	181	0
Lobelia cardinalis	1922	9–12	95	9–22	0
Lythrum Salicaria	1922	6–10	84	6	4
	1923	7–82	67	6–10	9
Mimulus ringens	1923	14–28	56	28	0
Pentstemon Digitalis	1923	14	32	28	0
Penthorum sedoides	1922	18	52	28	0
	1923	18–181	23	28–233	0

[2] Standards in judging the effect of light are as follows: (1) If there is more germination in light than in darkness, light is said to be beneficial to germination; (2) if the germination in darkness is more than 15 per cent greater than that in light, darkness is said to be beneficial to germination; (3) if the average germination in light is within 5 per cent of being equal to that in darkness, and the germination in no individual experiment differs by more than 20 per cent between light and darkness, light is said to have no marked effect upon germination.

TABLE I—*Continued*

Name	Year Collected	Light		Dark	
		Days	Percentage germination	Days	Percentage germination
Physalis virginiana	1923	3–86	59	10–119	43
Phytolacca decandra	1923	36	72	84	0
Plantago major	1923	10	16	19	0
Potentilla recta	1923	7–165	5	7–68	12
Potentilla arguta	1924	3–12	52	8–88	9
Pseudera quinquefolia	1923	13–32	48	12–34	7
Radicula palustris	1923	8–76	30	30–233	0
Rhamnus cathartica	1924	23–59	44	23–59	24
Saponaria officinalis	1924	6–46	30	6–24	4
Scrophularia leporella	1923	19–28	44	28	0
Scutellaria lateriflora	1922	11	88	21	0
	1923	11–94	21	20–227	0
Solidago nemoralis	1923	.....	64	109	0
Solidago rugosa	1923	91	52	109	0
Spiraea tomentosa	1924	15–41	50	41	2
Tanacetum vulgare	1923	3–23	96	5–8	68
Verbascum Blattaria	1923	2–73	59	4–56	34
	1924	24	70	24	4
Verbena hastata	1923	28	33	0	0
Verbena urticaefolia	1923	16–97	17	91–225	0

TABLE II

SEEDS UPON WHOSE GERMINATION DARK HAS A BENEFICIAL EFFECT

Name	Year collected	Light		Dark	
		Days	Percentage germination	Days	Percentage germination
Polygonatum biflorum	1923	9–146	13	9–146	32
Smilacina racemosa	1923	88–240	0	72–147	16
	1924	199	0	38–63	5
Smilacina stellata	1923	37	4	6–37	84

TABLE III

SEEDS UPON WHOSE GERMINATION LIGHT HAS NO MARKED EFFECT

NAME	YEAR COLLECTED	LIGHT		DARK	
		Days	Percentage germination	Days	Percentage germination
Achillea millefolium	1922	21	64	12	96
Asclepias tuberosa	1923	8–33	23	12–188	24
	1923	4–33	77	3–36	73
	1924	6–20	60	6–39	90
Arisaema triphyllum	1923	57	96	63	96
Cassia marilandica	1923	34	20	34	24
Cichorium Intybus	1923	54	84	29	72
Epilobium molle*	1923	68	88	163	80
Gnaphalium polycephalum	1922	5–24	52	5–36	35
Lilium philadelphicum	1923	109	84	91	84
Oenothera biennis	1923	11	72	15	60
Physalis virginiana	1923	16	72	56	56
Rudbeckia hirta	1923	5	56	12	52
Silene latifolia	1923	9	92	13	88
Solanum Dulcamara	1923	5	92	13	96
Tanacetum vulgare	1923	7	92	8	88
Tragopogon pratensis	1923	10	80	10	100
Veronica virginica	1923	28	44	68	32
Viburnum acerifolium	1923	236	64	200	64
Viburnum prunifolium	1923	177	55	178	52

* In this instance the dark plate was brought into light at the 152d day.

TABLE IV

SEEDS UPON WHOSE GERMINATION NIPPING HAS A BENEFICIAL EFFECT

NAME	NOT NIPPED				NIPPED			
	Light		Dark		Light		Dark	
	Days	Percentage germination	Days	Percentage germination	Days	Percentage germination	Days	Percentage germination
Apocynum cannabinum	6	44	6	4	6	72	6	40
Cassia marilandica	6	4	12	4	7	84	3	68
Ceanothus americana	5	4	8	8	26	0	8	36
Dioscorea villosa	30	0	30	0	30	4	30	16
Phytolacca decandra	30	0	30	0	3–18	40	7–12	48
Rhus copallina	28	0	28	0	10	24	19	48
Rhus glabra	28	0	28	0	18	48	14	28
Sagittaria latifolia					64	77	104	93
Solidago bicolor	26	8	17	16	26	28	12	8
Solidago nemoralis	26	0	12	0	26	20	12	8
Verbena hastata	15	18	33	0	5–12	32	5–7	40
Verbena urticaefolia	91	0	91	0	5	24	5	56

The highest percentage of germination (that is, 20 per cent in 33–67 days) of seeds of *Mitchella repens* occurred when the seeds were treated as follows. The berries were kept in the dark at a temperature of 5°–10° C. for six weeks. The berries were then mashed and the pulp floated from the seeds. Then the seeds were nipped and placed under germinative conditions in the dark.

The best percentage of germination (that is, 52 per cent in a range of 15–49 days) of seeds of *Celastrus scandens* occurred when the seeds were treated as follows. The seeds were collected from the vines on January 31. They were removed from their coats on March 9 and placed under germinative conditions in the dark at a temperature of 5°–10° C.—ESTHER MITCHELL, *Department of Botany, Vassar College, Poughkeepsie, New York.*

CURRENT LITERATURE

BOOK REVIEWS

Chemical basis of growth and senescence

An extensive literature concerning the growth rate of animals and plants has sprung into existence since ROBERTSON (1908) first suggested that growth curves of organisms are similar to the rate curves of autocatalyzed monomolecular chemical reactions. This literature has been summarized by ROBERTSON[1] in book form, and his theory of autocatalysis of growth is presented fully, with such evidence as seems to support his interpretation. The introduction presents growth as a self-accelerated process, carried on by some "master reaction," which is conceived as probably multimolecular, although protoplasmic breakdown may be monomolecular. The first part of the growth curve, when growth is increasing in rate, is called the autokinetic phase, and the later part, where the growth rate is decreasing, is called the autostatic phase of growth.

The succeeding chapters consider the growth cycles in man, animals, and plants, and in unicellular organisms. The chapter on growth of unicellular forms considers allelocatalysis, and the significance of the lag period. The substrates of growth, inorganic salts, amino acids, and accessory vitamines as distinct from the catalysts of growth are considered in two chapters.

The autostatic phase is treated in several chapters dealing with such retarding influences as bodily dimensions, physiological differentiation, senescence, the influence of differentiation on the distribution of nutrients, metabolic rates, etc., and the relation of nutrient levels to growth rates.

The concluding chapters deal with hyperdifferentiation, the action of special chemical agents, such as lecithin, thyroxin, and others, and growth and evolution. An appendix provides tables for the computation of curves of autocatalysis. The literature citations number well over 500.

Briefly stated, ROBERTSON conceives growth as an autocatalyzed process, the autocatalyst having its origin in the nucleus of the cell. This nuclear catalyst is partitioned between nucleus and cytoplasm and pericellular medium during cell division when the nuclear membrane breaks down. The autocatalyst may be the substance called "bios" by WILDIERS 25 years ago. As the autocatalyst accumulates with successive cell divisions, it comes finally to exist in excess in older cells. This accumulation of catalyst tends to suppress the formation of more catalyst, with accompanying retardation of growth rates, so that "the

[1] ROBERTSON, T. B., The chemical basis of growth and senescence. 8vo. pp. viii+389. *figs.* 45. Philadelphia: Lippincott.

rate of development of the community (of cells), therefore, reflects the rate of accumulation of the autocatalyst in the pericellular media."

That ROBERTSON thinks his theory may ultimately explain the riddle of development is indicated in his preface, in which he refers to BERGSON, who has expressed the belief that the scientific method can never provide a solution of this puzzling problem. He calls the book a preliminary essay toward that interpretation of development which BERGSON declares to be intellectually impossible.

Among plant physiologists there has also been much discussion, and the subject has been summarized by RIPPEL[2] for the higher and lower plants. He divides the discussion into two main sections following an introductory statement of viewpoints, the growth curve, and the curve of yield.

While it is of interest to express growth rate curves in terms of mathematical formulas, these attempts to express growth in terms of autocatalytic phenomena are leading us off into the wilderness. In the sense that an organism makes its own enzymes, growth may be autocatalyzed; but the S-shaped curve of growth rates, observed in nearly all studies, is in itself not evidence of autocatalyzed growth in the ROBERTSON sense at all.

Evidence is accumulating to show that the S-shaped curve of growth rates in plants can be explained on the basis of nutrition and correlation, with the decided advantage that there is tangible evidence to support the interpretations. The work of MURNEEK,[3] [4] and POPP (unpublished) indicates that the slow growth of early life is related to the cotyledonary food supplies. Growth speeds up as the leaves become able to manufacture increasing food supplies, but begins to decrease as soon as reproductive organs divert the nutrient supplies to the reproductive structures. We do not need to call upon hypothetical catalysts to account for such S-shaped curves of growth. We need decidedly less theorizing and more solid experimental evidence and hard-headed reasoning in connection with these growth problems.—C. A. SHULL.

Physical chemistry in biology and medicine

Physical chemistry has become an indispensable tool to the investigator of physiological processes. Any assistance to the physiologists who are attempting to make good the deficiencies in earlier training along these lines should be welcome. MCCLENDON and MEDES[5] have prepared a book to meet the needs

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[2] RIPPEL, AUGUST, Wachstumsgesetze bei höheren und niederen Pflanzen. Naturwissenschaft und Landwirtschaft. Heft 3. pp. 90. Freising-München. Datterer. 1925.

[3] MURNEEK, A. E., Correlation and cyclic growth in plants. BOT. GAZ. 79:329–333. 1925.

[4] ———, The effects of correlation between vegetative and reproductive functions in the tomato. Plant Physiology 1:3–57. 1926.

[5] MCCLENDON, J. F., and MEDES, GRACE, Physical chemistry in biology and medicine. 8vo. pp. 425. Philadelphia: Saunders. 1925.

of those who are trying to master the fundamental applications of physical chemistry to biological investigations. The treatment of the subject is divided into two sections, physico-chemical and physiological.

The first group of chapters takes up the fundamental notions of mass, volume, atomic structure, colloidal state, intermolecular attractions, osmotic phenomena, dissociation, conductivity, mass action and equilibria, hydrolysis, hydrogen ion, buffers, indicators, and oxidation-reduction potentials. The treatment of these topics in some cases strikes the reviewer as too elementary to be very helpful, except in the very beginning of such study. This may not be such a serious fault, considering the group for whom it is intended; but the treatment does not go far enough into the theoretical considerations in many places. Numerous references, however, open the way to more serious usefulness of the methods of physical chemistry in biology.

The physiological section deals with the nature of radiant energy and photodynamic effects; atomic structure and physiological action; thermochemistry and calorimetry; colloidal state of biological materials; influence of hydrogen ion concentration on enzymes, bacteria, and in soils, water etc.; ionic equilibria in blood; osmosis; permeability; and surface forces. There are hundreds of references to the literature, mostly recent publications, and these help to make up for the inadequacy of treatment at various places. The aim of the authors is laudable, for it is much better that the inadequately trained investigator should be stimulated to make good his deficiencies, rather than to curtail and limit the field of research. The book should prove helpful to those struggling against limitations set by lack of training in the physico-chemical sciences.—C. A. SHULL.

The cell wall

Perhaps the feature which most sharply distinguishes plants from animals is the presence as a rule of a cell wall in the former. VAN WISSELINGH,[6] whose researches on cork are well known, has recently gathered together what is known about this distinctive plant feature into a most convenient and useful volume.

The work is divided into seven chapters, dealing respectively with Cellulose, Hemicelluloses and pectic substances, Lignin and lignification, Suberin and cutin, Chitin, Mineral components, and Structure and growth. Each chapter is subdivided into a number of sections, each complete in itself and dealing with such topics as chemical composition, effect of reagents, decomposition products, and microchemical detection and distribution in nature. A most valuable feature is the extensive bibliography appended to each section. The literature is very well summarized down to 1921, and an *addenda* chapter brings it down into 1924, so that it is really quite up-to-date.

In such a work one might expect to find much space devoted to a discussion of the various kinds of cell walls and cell forms, but the author in his foreword

[6] VAN WISSELINGH, C., Die Zellmembran. 8vo. pp. vii+266. Berlin: Gebrüder Borntträger. 1925.

definitely delimits his subject so as to exclude this descriptive detail, placing the emphasis rather on the physiological than the morphological side. The only notable omission which the reviewer has detected is the absence of any suggestion as to the origin of the constituents of the cell wall. It may be that the author felt it to be outside his province to inquire into the past history of the building stones found in the wall.

The author has not done further research on the adipo-celluloses since the end of the last century, but has been studying the growth and structure of cell walls more recently, so that the only new studies of his own are to be found in the last chapter. He has fairly and ably summarized the researches and theories of other workers in every phase of the subject, however, and has produced a very valuable source book for reference. An author-index as well as a subject-index adds to its usefulness.—H. S. WOLFE.

Fruit growing

Another excellent book has been added to the literature of horticultural science. Out of a rich experience CHANDLER[7] has prepared a work which should be read by all who are interested in the physiological phases of the life of fruit trees, and particularly by those who expect to devote themselves to fundamental research underlying the practical arts of orchard management and fruit production.

The early chapters deal with the growth habits of fruit trees, the factors influencing bud formation, and the problem of the rest period or dormancy. The student will find in these chapters well balanced and discriminating discussions of the conditions which influence fruit bud formation, such as the carbohydrate-nitrogen relationship, ringing, root pruning, etc. Succeeding chapters deal with root and soil problems; water relations, including the responses of fruit trees to irrigation practices; and the management of orchard soils. Fruit setting, self sterility, fruit thinning, and especially pruning of trees receive careful and detailed consideration. The later chapters are devoted to the climatic responses of fruit trees, particularly light and heat responses, and the physiological changes associated with ripening, harvesting, and storage of fruits.

Most of the 27 chapters close with a summary, which aids materially in maintaining a well balanced point of view on the part of students. There is an extensive bibliography of nearly 1400 titles at the close of the work. The citations are arranged by subject to correspond to the chapters, and offer a well chosen introduction to the literature of this field.

The book is very meritorious from the standpoint of contents and point of view; it will undoubtedly receive the welcome it deserves at the hands of plant physiologists and horticulturists.—C. A. SHULL.

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[7] CHANDLER, W. H., Fruit growing. 8vo. pp. xvi+775. figs. 60. New York: Houghton Mifflin Co. 1925.

Growth of biology

A knowledge of the historical background of science is not only very desirable, but well nigh indispensable to both teachers and investigators. The history of biology, like that of physics and chemistry, is replete with the romance of discovery and achievement. The late Professor LOCY recognized the importance and significance of the history of biological science, and at the time of his death left the manuscript of a book[8] which will be eagerly read by those who have been delighted with his earlier work, *Biology and its makers*. The book should be read by all who desire an understanding of the romantic development of the great ideas, principles, and speculations of biological science and philosophy.

The development of botany and zoölogy runs parallel, and the author treats these sciences together in telling his story. Each has contributed equally to the study of microscopic structure, the investigation of protoplasm, the formulation of the cell theory, and the other generalizations of modern biology.

Students of botanical history will be interested especially in the chapters on the natural history of antiquity, and of the Greek and Roman periods, the story of the herbals of the sixteenth century, the contribution of LINNAEUS, the period from LINNAEUS to SCHLEIDEN, and the period dominated by HOFMEISTER'S work.

The book is written in a charming, entertaining style, of which the author was a master.—C. A. SHULL.

Essentials of systematic pomology

Students of systematic pomology will find much in this book by DRAIN[9] to commend it. It aims to be a textbook for student use, and is a well organized presentation. It is written in clear readable style, and contains much information that will be of value to those who must know the varieties of pomes and other fruits accurately.

There are twenty-one chapters, arranged in such a way that the student makes a careful study of the various fruits, and then is introduced to the classification of the group. The first five chapters deal with the pomes, the second five with the drupaceous fruits, and the following eight with small fruits. The last three chapters consider southern fruits (citrus, olive, pineapple), nut fruits, and nomenclature ot fruits, with the code adopted by the American Pomological Society.

The author makes effective use of his observations and experience with students, with the result that the book is interesting, even to an amateur. It also contains much valuable information for those who may be interested in producing fruit in their own gardens.—C. A. SHULL.

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[8] LOCY, W. A., Growth of biology. 8vo. pp. xiv+481. *figs.* 140. New York: Henry Holt. 1925.

[9] DRAIN, B. D., Essentials of systematic pomology. 8vo. pp. vi+284. New York: John Wiley & Sons. 1925.

NOTES FOR STUDENTS

Mechanism of oxidation.—Several recent papers deal with the oxidase system in plants. GALLAGHER[10] has suggested, not without opposition, that the "oxygenase" of BACH and CHODAT is not necessary to the system. From the potato and mangold roots, he has been able to extract a lipin-like autoxidizable body, which he believes may function as a peroxide former. In this way the production of the organic peroxide of the system would need no catalyst. Many such autoxidizable compounds exist in plants, for the unsaturated terpenes are all able to absorb oxygen. Among these may be mentioned limonene, cumene, terpineol, carvone, etc., fairly common constituents of plant extracts.

The nature of the peroxidase component is considered in a second paper,[11] in which the claim is made that peroxidase activity is associated with aliphatic aldehydes, but atmospheric oxygen is required to produce the peroxidase through formation of some oxide. Substances behaving as peroxidases are generally characterized by the presence of an oxide group of the type =O, and GALLAGHER believes that some aldehyde derivative like R.CH=O=O is responsible for the peroxidase activity. The peroxidase of mangolds has been investigated[12] with reference to its thermostability. Although its activity is inhibited by heating, the effect is temporary, reactivation occurring on standing in the cold. The peroxidase is associated with iron, and the opinion is expressed that iron may be the oxygen carrier in the formation of the aldehydic monoperoxide.

GALLAGHER's position is criticized by ROBINSON,[13] and ONSLOW,[14] who maintain that catechol derivatives form the basis of the organic peroxides of the oxidase system, with two enzymes: (a) oxygenase to catalyze the formation of peroxide from catechol; and (b) peroxidase to catalyze the splitting of the peroxide during oxidation.

The main contention is that there are so many autoxidizable bodies in the plant, that the lecithin-like compounds cannot be singled out for such a function. Formic, acetic, valeric, benzoic, salicylic, and cinnamic aldehydes, caprylic alcohol, oleic and pyruvic acids, many terpenes, and most plant extracts show autoxidation.

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[10] GALLAGHER, P. H., The oxygenase of BACH and CHODAT; function of the lecithins in respiration. Biochem. Jour. **17**: 515–529. 1923.

[11] ———, An investigation of substances capable of behaving as peroxidases. Biochem. Jour. **18**: 29–38. 1924.

[12] ———, Observations on the thermostability of the peroxidase of the mangold. Biochem. Jour. **18**: 39–46. 1924.

[13] ROBINSON, MURIEL ELAINE, A comparison of certain oxidizing enzymes of the higher and lower plants. Biochem. Jour. **18**: 543–548. 1924.

[14] ONSLOW, MURIEL WHELDALE, The oxygenase of the higher plants. Biochem. Jour. **18**: 549. 1924.

GALLAGHER'S reference to iron in connection with peroxidase is of interest. The influence of iron in the respiratory process has received attention by animal physiologists, but not so much by plant physiologists. In a recent lecture, WARBURG[15] takes the position that iron is the only oxidizing agent in the living cell. He offers much interesting evidence for his view, which, even if not conclusive, should stimulate plant physiologists to study the relation of iron to these oxidase systems which have been proposed. Iron has not been excluded from the oxidase prep arations as made by ONSLOW and others, and WARBURG'S conception of the rôle of iron in respiration may have wide applicability in cellular oxidations of plants and animals.—C. A. SHULL.

Taxonomic notes.—YAMAMOTO,[16] in his first supplement to Icones Plantarum Formosanarum, publishes the results of collections of new material in four families. In addition to species already published and critical notes, 19 new species are described, one in Moraceae, 10 in Urticaceae (6 of them *Pilea*), 7 in Aquifoliaceae (all *Ilex*), and one in Convolvulaceae.

ROBINSON,[17] in continuation of his study of the Eupatorieae, has some new material from Mexico, including 10 new species of *Eupatorium*.

MUNZ and JOHNSTON[18] have published an account of 12 species of *Oenothera* from South America, 3 of which are new.

JOHNSTON[19] has published descriptions of 23 new species of American plants, the largest contribution being 16 new species in *Fuchsia*.

VAN SLOOTEN[20] has published a very detailed revision of the Flacourtiaceae of the Dutch East Indies. It includes 16 genera, 3 of which (*Eleutherandra*, *Hemiscolopia*, *Mesaulosperma*) are new, representing 75 species, 10 of which are new. The largest genus is *Casearia*, with 18 species.

NAKAI[21] has described two new genera of Bambusaceae, segregates from *Arundinaria*. *Pleioblastus* includes 7 species from China and Japan, while *Indocalamus* includes 7 species from China, India, and the Philippines.

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[15] WARBURG, O., Iron, the oxygen carrier of respiration-ferment. Science N.S. **61**:576–582. 1925.

[16] YAMAMOTO, YOSHIMATSU, Supplementa Iconum Plantarum Formosanarum I. pp. 47. 1925.

[17] ROBINSON, B. L., Records preliminary to a general treatment of the Eupatorieae. V. Contrib. Gray Herb. N.S. no. 75. pp. 1–15. 1925.

[18] MUNZ, P. A., and JOHNSTON, I. M., The Oenotheras of northwestern South America. Contrib. Gray Herb. N.S. no. 75. pp. 15–23. 1925.

[19] JOHNSTON, I. M., Some undescribed American Spermatophytes. Contrib. Gray Herb. N.S. no. 75. pp. 27–40. 1925.

[20] VAN SLOOTEN, D. F., The Flacourtiaceae of the Dutch East Indies. Bull. Jard. Bot. Buitenzorg III. **7**:291–421. 1925.

[21] NAKAI, T., Two new genera of Bambusaceae. Jour. Arnold Arboretum **6**:145–153. 1925.

REHDER[22] has described a new bigeneric hybrid, discovered by JACK in Idaho on the summit of Elk Butte. The parents of the hybrid are said to be *Sorbus sitchensis* and *Amelanchier florida*. While several bigeneric hybrids are known among the Pomoideae of Rosaceae, the present hybrid (*Amelasorbus*) is of interest because the two genera producing it are much less closely related than those producing the previously known hybrids.—J. M. C.

Ecological aspects of pathology.—That important pathological problems may be ecological in part is well illustrated by a recent study of the western yellow blight of the tomato by SHAPOVALOV.[23] It is shown that the occurrence of this disease is decidedly affected by weather conditions, the general fact being that the spread of the blight is favored by conditions that raise the rate of evaporation, and opposed by an increase in atmospheric humidity. The exact manner in which evaporation facilitates the development of the blight is not clear. Perhaps the fungus attack may be a secondary phenomenon following the abnormal development of the plant during periods of high evaporation.—H. C. COWLES

Bog xeropytes.—The old and unsettled problem of the real character of bog plants has recently had suggested a solution that appears plausible, and is certainly very suggestive and stimulating. Studying in the field the heath and bog plants of northwestern Germany, STOCKER[24] concludes that SCHIMPER'S theory of bog xerophytism is incorrect. Measuring the rate of transpiration of such plants, he finds that it is comparable with that of plants growing in other habitats; in fact, when the criterion of the ratio of daily transpiration to weight of roots is adopted, the heath and bog plants have a very high rate of water loss.

STOCKER also claims that the heather, *Calluna vulgaris*, is able to thrive only where atmospheric humidity is high, and in regions where there are dry summers only where it is protected by trees whose shade makes locally humid conditions. The xeromorphic character of the leaves of these ericaceous heath and bog plants are regarded as adaptations, to protect these plants from the high winds of winter storms that prevail in the regions of heaths and bogs. It is suggested that as these leaf forms protect against injury by high winds rather than against water loss, they be termed "anemomorphs" rather than "xeromorphs."—GEO. D. FULLER.

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[22] REHDER, ALFRED, *Amelasorbus*, a new bigeneric hybrid. Jour. Arnold Arboretum **6**: 154–156. 1925.

[23] SHAPOVALOV, M., Ecological aspects of a pathological problem (western yellow blight of tomatoes). Ecology **6**: 241–259. 1925.

[24] STOCKER, O., Die Transpiration und Wasserökologie nordwest deutscher Heide- und Moorpflanzen am Standort. Zeitschr. 1923.

———, Klimamessungen auf kleinstem Raum an Wiesen-, Wald-, und Heide, pflanzen. Ber. Deutsch. Bot. Gesells. **41**: 145–150. 1923.

———, Ökologisch-pflanzengeographische Untersuchungen an Heide-, Moor- und Salzpflanzen. Die Naturwissenschaften **12**: 637–646. 1924.

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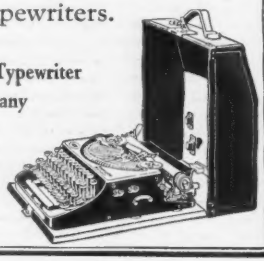

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